Recent Computer Technologies for an Innovative Cartographic Language

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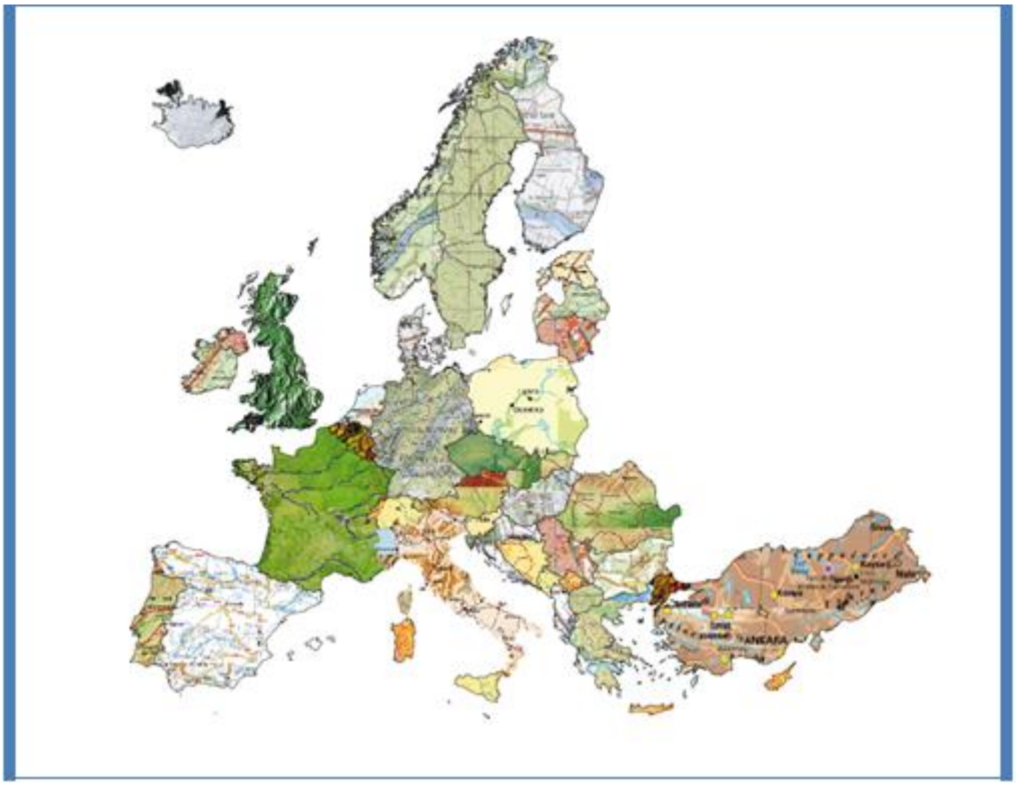
ESPON CARTOGRAPHIC LANGUAGE

INTERIM REPORT
Delivery 1 - May 2013
Review Report (Tasks 1, 2 and 3)



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INTRODUCTION

The present interim report is a review report on the cartographic language currently used for the representation of European territorial structures. This is part of the task requested by ESPON in the call for tender “ESPON Cartographic Language”. This call aims to “propose and develop a unique and innovative ESPON Cartographic Language for cartographic and graphic representations of (in particular) European territorial structures, trends, perspectives, policy impacts and policy priorities and to be useful and used as a practical guide for cartography related to ESPON”.

The purpose of the work requested is to develop a cartographic language matching the interests of policy makers involved in territorial policies, and liable to be easily understood by them.
The target audience is defined as “scientists and experts working on ESPON projects of the ESPON 2013 Programme as well as experts challenged with the processing of territorial policy development”.

Five fundamental points are identified for an effective and operational proposal:

- Modernisation and harmonisation of the existing cartographic language and introduction of innovations
- Inclusion of elements required for the establishment of cartographic standards Guidance for cartographic production within ESPON projects
- Proposal of concrete suggestions for cartographic illustrations/presentations
- Information on scope afforded by computer technologies and software development.

The first part of the work, as presented in this interim report involves refined analysis of the ESPON cartographic production, subdivided into three areas of study:
- the arrangment and the analysis of cartographic productions by all ESPON projects in the 2013 programme. The aim here is to identify strengths and weaknesses in ESPON cartographic production;
- the establishment of a map corpus concerning Europe, spatial planning and territorial development, produced outside the ESPON programme. The analysis of this corpus should enable us to identify and highlight "good practice" in the field of cartography, and also to focus on particularly original and effective practices in the area of graphic communication of political or scientific subject matter;
- the study of a whole range of developments and productions in the area of dynamic cartography and in specific geovisualisation environments. The idea is to provide expertise in these different environments in order to respond to the different methodological issues.

At each stage we will set out the strengths and weaknesses of the cartographic approaches analysed. We will conclude with a presentation of the layout of a Guide to be produced in tasks 4 and 5 to foster effective and innovating cartography. Several lines of reflection will thus be proposed on the subject of graphic representations and geovisualisation.

TASK 1 : CURRENT ESPON CARTOGRAPHIC LANGUAGE

Review of the cartographic language currently applied in the ESPON 2013 Programme.

The service provider is asked to review the cartographic language currently applied in the framework of the ESPON 2013 Programme by analysing maps from a minimum of 20 ESPON projects under Priorities 1, 2 and 3, and to present a structured overview of their strengths, weaknesses and consistency (in the use of symbols, colours etc.) in relation to the different themes and geographical contexts.

ESPON Cartographic production within the ESPON 2013 corpus will be explored in four directions:

- *Are the maps produced in ESPON projects effective and aesthetic ?*
- *Is the ESPON map production homogeneous ?*
- *Are the semiotic rules applied correctly?*
- *Are the maps easily understandable ?*

1. Presentation of the Corpus of maps in the ESPON 2013 programme

The cartographic production arising from the ESPON programme forms the first corpus for analysis. A fairly significant proportion is made up of the maps included in the different documents produced in ESPON between 2007 and 2013.

The formation of this corpus was guided by two inclusion criteria:
- solely cartographic documents that are included in final reports (or certain draft final reports) relating to the three priorities (P1, P2 and P3) up to February 2013 are retained; this condition is to ensure that the cartographic documents can be considered as published, with comparable production requirements, since they appear in disseminated reports.
- only cartographic documents considered by ESPON to be particularly relevant are retained as they appear in general in synthesis reports, scientific reports, or they are targeted cartographic communication documents that focus on European territorial dynamics (Espon Atlas, Map of the Month, Territorial Observation). It will be seen that these publication choose to publish numerous maps that are already in the reports of certain P1 or P2 projects. However they are nevertheless retained in duplicate (or more) in the general corpus. These duplicates on the one hand enable us to assess the scale of their dual use and on the other enable comparisons of different versions.

Finally, the ESPON 3.2 Scenario report which is scientifically outside the scope of ESPON 2013 programme was also retained because we think it is particularly innovating in the area of cartographic production and the issues broached.

The general corpus of ESPON maps is made up of 30 final (or draft final) reports published on the ESPON website[2] and 6 "relevant" publications[3]. The annexes of these reports were not used (they often include repeats of maps, unfinished sketch maps, or maps from earlier reports). The Executive Summary in each report when present was systematically consulted, so as to confront absence/presence of the same maps in the Executive Summary and the main text.

- ***Final Reports on projects from priorities P1 (12 reports out of 25), P2 (16 reports out of 21) and P3 (2 reports out of 12)***.

  - **Priority 1: Applied Research on Territorial Development, Competitiveness and Cohesion**, is thematically defined by the demands of policy makers. The projects create Europe-wide, comparable information and evidence on territorial potential and challenges, focusing on opportunities for success for the development of regions and cities. The projects have produced several maps and graphic illustrations that can be used for the analysis. Numerous final reports are already available (12 reports, 256 figures).

    - ✓ ATTREG *(Attractiveness of European Regions and Cities for Residents and Visitors)*: 19 figures
    - ✓ ARTS *(Assessment of Regional and Territorial Sensitivity)*: 76 figures
    - ✓ DEMIFER *(Demographic and Migratory Flows Affecting European Regions and Cities)*: 12 figures
    - ✓ EDORA *(European Development Opportunities in Rural Areas)*: 13 figures
    - ✓ CLIMATE *(Climate Change and Territorial Effects on Regions and Local Economies)*: 26 figures
    - ✓ FOCI *(Future Orientation for Cities)*: 14 figures
    - ✓ GEOSPECS *(Geographic Specificities and Development Potentials in Europe)* : 10 figures
    - ✓ EU-LUPA *(European Patterns of Land Use)*: 5 figures
    - ✓ ReRISK *(Regions at Risk of Energy Poverty)*: 21 figures
    - ✓ SGPTD *(Secondary growth poles in territorial development)*: 13 figures
    - ✓ TERCO *(European Territorial Cooperation as a Factor of Growth, Jobs and Quality of Life)*: 29 figures
    - ✓ TIPTAP *(Territorial Impact Package for Transport and Agricultural Policies)*: 18 figures

  - **Priority 2: Targeted Analyses on User Demand**, represent a type of project supporting the use of existing results in partnership with different groups of stakeholders. Introducing a new approach to the generation of project ideas as well as to the implementation of projects, Targeted Analyses provide an opportunity to stakeholders for: (1) enhancing their understanding of the larger territorial context, (2) making comparisons with other territories, regions and cities, and (3) including a European perspective in considerations on the development of their territories. These projects have enabled the various researchers to produce very diverse maps and graphics in terms of graphic semiology and innovation themes. (12 documents, 158 figures – 4 documents with no figure).

[2] http://www.espon.eu:Menu_Projects/
[3] http://www.espon.eu:Menu_Publications/

- ✓ AMCER *(Advanced Monitoring and Coordination of EU R&D Policies at Regional Level)*: 0 figure
- ✓ BEST METROPOLISES *(Best Development Conditions in European Metropolises: Paris, Berlin and Warsaw)*: 15 figures
- ✓ CAEE *(The Case for Agglomeration Economies in Europe)*: 10 figures
- ✓ EATIA *(ESPON and Territorial Impact Assessment)*: 0 figure
- ✓ EUROISLANDS *(The Development of the Islands – European Islands and Cohesion Policy)*: 10 figures
- ✓ METROBORDER *(Cross-Border Polycentric Metropolitan Regions)*: 24 figures
- ✓ POLYCE *(Metropolisation and Polycentric Development in Central Europe: Evidence Based Strategic Options)*: 15 figures
- ✓ PURR *(Potential of Rural Regions)*: 0 figures
- ✓ RISE *(Identifying and Exchanging Best Practices in Developing Regional Integrated Strategies in Europe)*: 4 figures
- ✓ SEMIGRA *(Selective Migration and Unbalanced Sex Ratio in Rural Regions)*: 8 figures
- ✓ SS-LR *(Spatial Scenarios: New Tools for Local-Regional Territories)*: 13 figures
- ✓ SURE *(Success for Convergence Regions' Economies)*: 0 figure
- ✓ TeDi *(Territorial Diversity in Europe)*: 13 figures
- ✓ TPM *(Territorial Performance Monitoring)*: 4 figures
- ✓ Tran SMEC *(Transnational Support Method for European Cooperation)*: 38 figures
- ✓ ULYSSES *(Using applied research results from ESPON as a yardstick for cross-border spatial development planning)*: 4 figures

- **Priority 3**: **Scientific Platform and Tools,** considered as a core element in a European territorial knowledge base. The three main mutually supportive actions are the ESPON 2013 Database, the development of Territorial Indicators and the Territorial Monitoring and Reporting System. Considerable input to the ESPON Scientific Platform is generated from Applied Research projects and Targeted Analyses delivering their indicators, typologies, methodologies, maps, and models to ESPON. (2 documents, 16 figures)

  - DATABASE *(Espon Data Base 2013)*: 12 figures
  - INTERCO *(Indicators of Territorial Cohesion)* : 4 figures

▪ ***Specific publications (214 figures)***

- **Synthesis Report** [4](1 document, 28 figures), First ESPON 2013 Synthesis report: New Evidence on Smart, Sustainable and Inclusive Territories. October 2010 Report. This ESPON Report presents a synthesis of results from the main Applied Research projects undertaken by the ESPON 2013 Programme. It is also provided with examples from Targeted Analyses delivered to stakeholders supporting the use of results by Member

[4] http://www.espon.eu/main/Menu_Publications/Menu_SynthesisReports/

States, regions and cities. (…) The report does not only make efforts to present comparable facts at regional and local level. It also contains new evidence on the European territory seen in a worldwide perspective, which nowadays is increasingly necessary for the competitiveness of the EU. (…)The report is the first in a series of three ESPON Synthesis Reports which all aim to communicate major ESPON results on numerous ongoing research themes relevant for integrated, place-based policy considerations.

- **Scientific report**[5] (1 document, 20 figures), First ESPON 2013 Scientific Report: Scientific Dialogue on Cities, Rural Areas and Rising Energy Prices. December 2010 Report. "The First ESPON 2013 Scientific Report presents the methodologies used within ESPON projects to explore comparative advantages and develop concepts, indicators, typologies and European maps on territorial development, competitiveness and cohesion through a dialogue among researchers, practitioners and policy makers. The three scientific papers included in this report (ReRisk, FOCI and EDORA) address the importance of metropolitan agglomeration, the potential of rural areas, the territorial impact and opportunities for the production of renewable energy sources. The aim of this report is to substantially contribute to scientific dialogue among researchers and experts across Europe aiming to build a scientific base for future policy development."

- **Territorial Observations**[6] (6 documents, 58 figures), "aim to provide policy makers and practitioners with short and concise information on important new evidence of various dynamics in the European territory, its regions and cities".

  - ✓ No. 1 : Population development and migration (8 maps or graphic illustrations)
  - ✓ No. 2 : Accessibility (10 maps or graphic illustrations)
  - ✓ No. 3: Economic Performance of European Regions (7 maps or graphic illustrations)
  - ✓ No. 4: Internet Roll-out (10 maps or graphic illustrations)
  - ✓ No. 5: Creative Workforce (9 maps or graphic illustrations)
  - ✓ No. 6: Regions and cities in the global economy (11 maps or graphic illustrations)

- **Maps of the month**[7] (18 documents, 23 figures). The maps presented via this medium enable ESPON to valorise a particular result in one of its on-going or completed projects. In February 29013, 19 maps had been published (in 20 items - two "Maps of the Month" opted for a focus not on maps but on data or the "synthesis report", at the time of publication)

  - ✓ Gender Imbalances in European Regions
  - ✓ Attractiveness of Regions to Migrants and Visitors
  - ✓ Evolution of cities servicing global capital

[5] http://www.espon.eu/main/Menu_Publications/Menu_ScientificReports/
[6] http://www.espon.eu/main/Menu_Publications/Menu_TerritorialObservations/
[7] http://www.espon.eu/main/Menu_Publications/Menu_MapsOfTheMonth/

- ✓ Climate change and Europe’s regions
- ✓ European Regions 2010: Economic Welfare and Unemployment
- ✓ Internet Roll-Out in the EU Regions
- ✓ Wind Power and Photovoltaic Potential
- ✓ Territorial Impact of Transport Policy Scenarios
- ✓ Economic Performance, 2006
- ✓ Performance of Less Accessible Regions, 2006
- ✓ The Relation between Accessibility and Economic Development, 2006
- ✓ Potential Accessibility by air, Change of Relative Position of Regions, 2001-2006
- ✓ Population growth in EU and its neighbourhood, 2030
- ✓ Natural Population Change and Migration in Europe, 2001-2005
- ✓ EU energy prices and self-sufficiency, 2001
- ✓ Migrants in EU 27+2, 2000
- ✓ World Trade, 1996-2000
- ✓ World demographic and economic evolutions, 1952-1998

- **ESPON Atlas 2006** (1 document, 72 figures) Mapping the structure of the European territory.
  The ESPON Atlas provides a synoptic and comprehensive overview of findings from ESPON Projects in the 2006 Programme. The results have been compiled thematically and set out in the form of synthesis maps which combine results from different projects. These synthetic maps are prefaced by original project maps to provide users with more in-depth background information.

- **Scenario 3.2** (1 document, 13 figures), Spatial scenarios in relation to the ESDP and EU Cohesion Policy. “The main objective of the project is to develop spatial scenarios which should on the one hand be prospective, capable of prognosis with reference to a laissez-faire scenario on themes relating to ESPON and policy orientations of the ESDP.”

The corpus includes 644 figures. A figure is defined by being indexed in the Figures contents page, with a number and a title. Figures can comprise a single illustration (map, graphic presentation, or table) or can be made up of several. Thus the 644 figures amount to 908 illustrations, giving an average 1.4 illustrations per figure.

A general analysis grid (Table 1.1) termed "systematic count" is applied to this corpus, and enables the extraction of a few global indicators.

Category	Description	Objectives
Identifying the figure	Figure identifier (id) Report containing the figure Page n° Report date Index title of the figure Title in *map kit* Parent (identifier) Published more than once in identical form (Y/N) Executive Summary (Y/N/NA)	10 criteria enable precise identification of the figure analysed in the ESPON corpus. They mainly aim to calculate the mean number of maps produced, and whether they were published once or several times in different publications. The aim is also to assess the links between subject matter and title.
Composition of the figure	N° of maps N° of graphics N° of tables N° of other illustrations Position of figures on page when several (T/B/L/R)	Indexed figures can comprise several types of graphic illustrations (maps, statistical diagrams, tables, etc.). What is the relationship among these graphic elements? Are maps the most common form?
Description of the figure	Format (mm) Legend (Y/N) Grid Spatial cover Mode of representation Date of data	This category enables the main characteristics of the maps and their composition to be enumerated. Only maps are retained in this analysis; a first approach of the formats, grids, spatial cover and representation modes most frequently used in ESPON in recent years.
Commentary	Remarks	Highlighting original representations, noting elements not taken into account by the evaluation grid.

Table 1.1: Grid for a Global analysis of the ESPON cartography corpus

The distribution of figures according to the type of report (Figure 1.1) shows a marked predominance of figures derived from projects, in particular P1 applied research (40%). Specific publication reports for their part represent nearly 33% of the corpus.

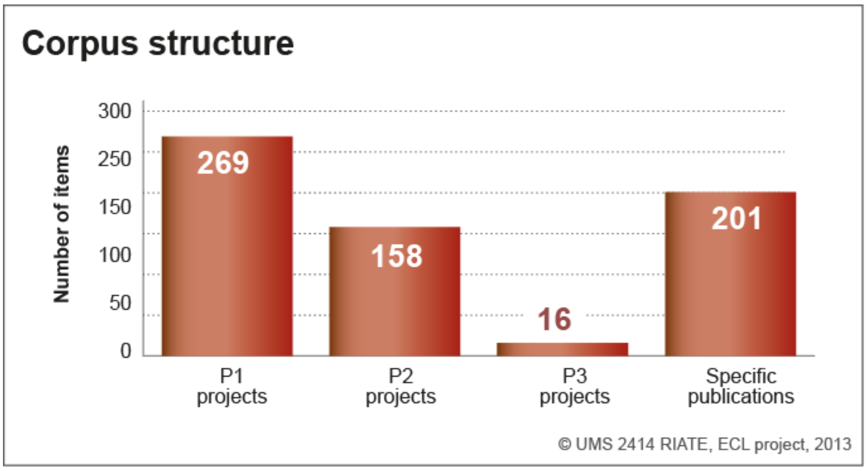


Figure 1.1: Publication Types in the global ESPON corpus

This corpus needs refining via an analysis of the typology of the illustrations provided (Figure 1.2) and of the text/image ratio (Figure 4).

Among the 908 illustrations in the overall corpus, 83.8% are maps (761), 10.7% are various graphic elements (pie charts, bar charts), and 5.5% are tables or schemas.

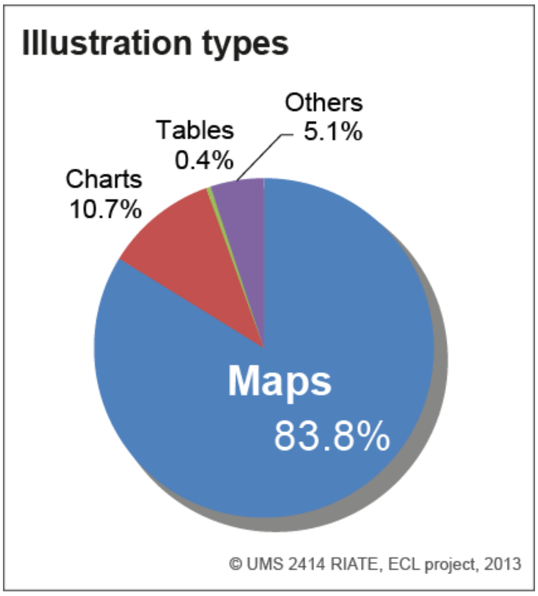
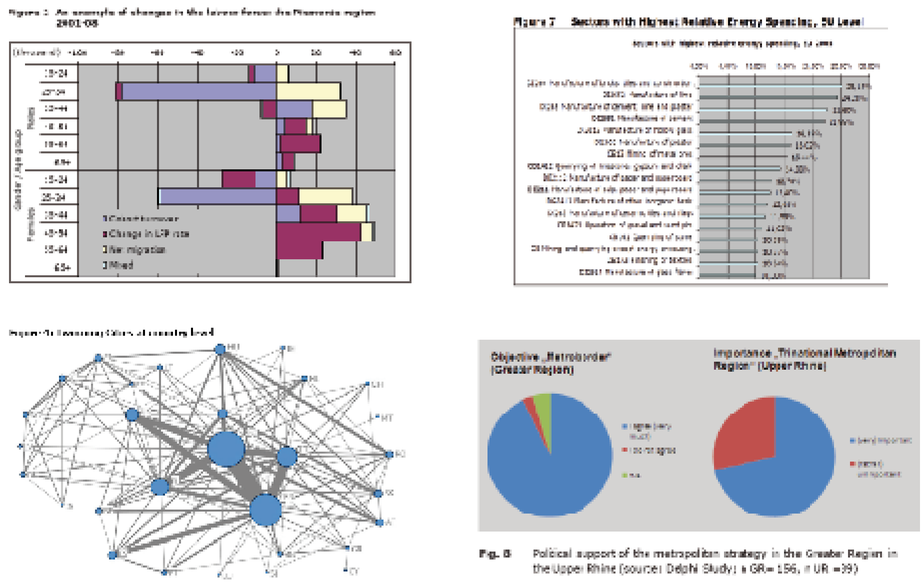


Figure 1.2: Illustration Types in the global ESPON Corpus

Overall, graphs and tables presented in the ESPON publications are not frequent (only 16% of the corpus analysed). Many projects include graphic illustrations in their interim reports to back up their demonstrations, but they often disappear from the final reports.

These graphic elements are mainly bar charts (80%) or pie charts (Figure 1.3). A few other graphic types also occur, such as network diagrams, tree classifications and flowcharts. No graphic representation was identified as genuinely innovating in the corpus, whether in form or design.



Sources: P1 Project Demifer Main report p.18; P1 Project ReRisk Main report p.79; P1 Project Terco Main report p.10; P2 Project, Métroborder final report p.59

Figure 1.3: Graphics in the ESPON Corpus

4 provides an understading of the ratio between text and illustrations. This ratio provides a good indication of the place of iconography in "Esponian" approaches. We make an exception for "Map of the Month", where obviously the image-text ratio is 100% because of the very nature of the publication. Territorial Observation reports have the highest image-text ratio, with an average of 50% illustrations. Again, it can be thought that these publications are far too specific to be representative, since it is their function to produce numerous illustrations.

The P1 applied research projects have an image-text ratio (Figure 1.4) that is more favourable than the projects concerning the other priorities (on average 23.3% illustrations, the best ratio being registered for the ESPON Climate project with 32% figures in the final report). The Synthesis Report does no better with 25% figures on average.

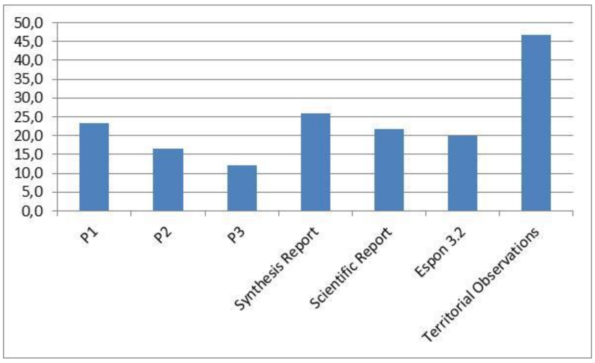


Figure 1.4: Image/text ratio in the ESPON Corpus

For the rest of the analysis we have chosen to consider only the graphic objects that are maps, amounting to 84% of the corpus.

This second corpus (525 figures and 761 maps) exhibits a different distribution. Figure 1.5 first of all shows a marked predominance (87%) of figures made up of a single map. However certain figures comprise up to 9 maps.

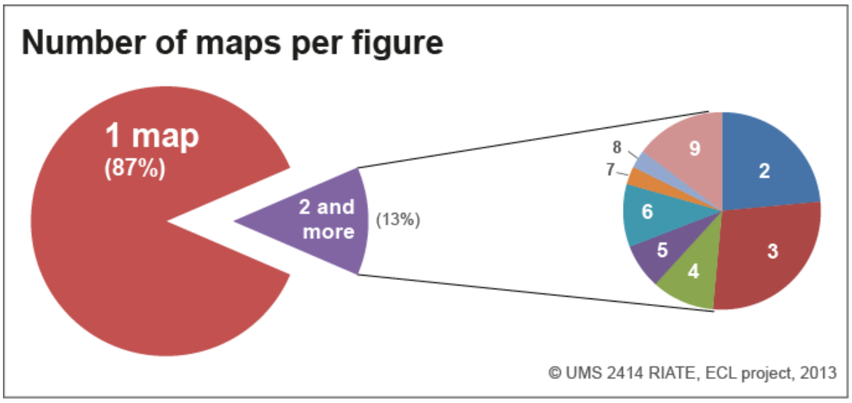


Figure 1.5: Numbers of maps per figure in the reduced Corpus

If we consider this same information across projects (Figure 1.6) it then appears that it is predominantly the specific publications that produce the largest numbers of maps (35.5% of the corpus of maps, with 270 maps for 214 figures, or an average of 1.28 maps per figure), followed by targeted analysis (P2 projects; 244 maps (32%) for 158 figures, or 1.54 maps per figure). P1 projects account for only 28% of the corpus with 0.8 maps per figure.

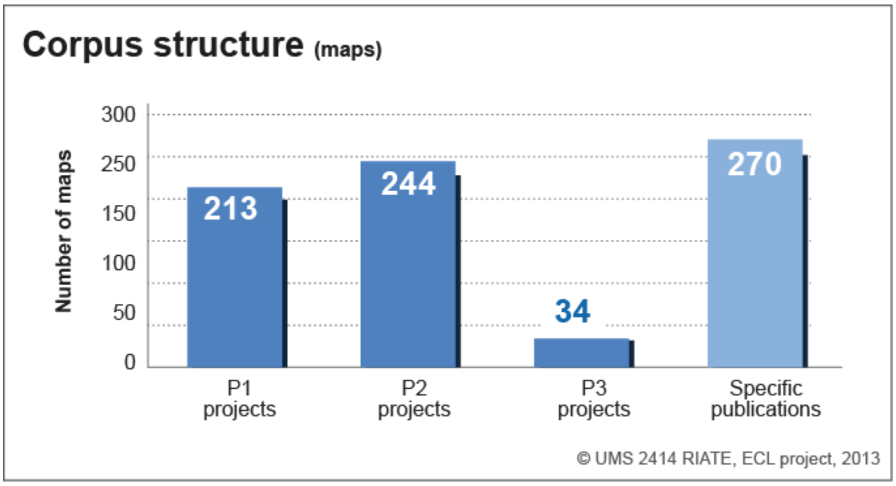


Figure 1.6: Publication types in the reduced ESPON corpus

Analysis of the number of maps per figure thus rebalances this new corpus. P3 projects reports (2.13 maps per figure) come first (Figure 1.7). The maps retained in P3 reports are in fact not very numerous (34 maps for 16 figures), but, overall, maps do seem to be a priority with a clear technical and operational objective (DatBase and Interco), which explains the high ratio of maps to figures.

Detailed analysis according to document type (breakdown of the different specific reports) shows a hierarchy that alternates specific reports and project reports: the Synthesis Report (1.82 maps per figure), then P3 projects, then P2 (1.54), the ESPON atlas (1.47), the Scenario 3.2 Report (1.31), the Scientific report (1.1), the Map of the Month[8], and finally Territorial Observation and P1 projects (0.83).

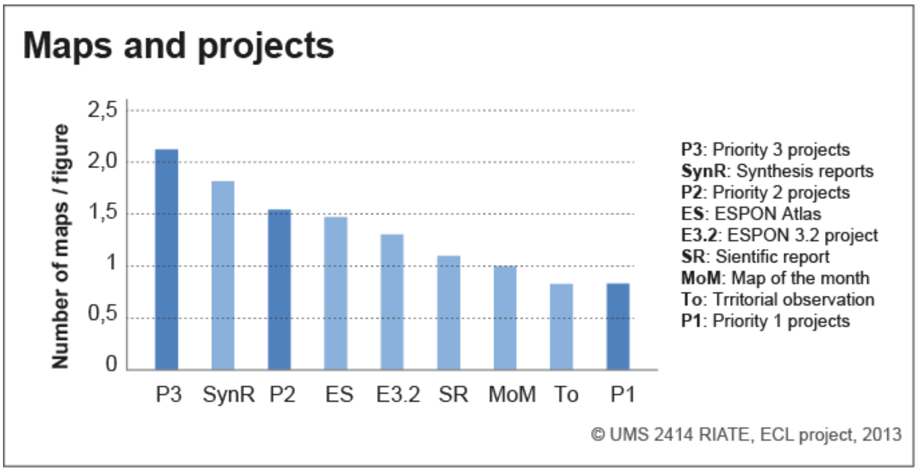


Figure 1.7: Hierarchy across publication types

Hereunder is presented the map corpus providing an overall analysis using a systematic count grid.

2. General analysis of the map corpus of the ESPON 2013 programme

Setting aside the identification components, the figures are analysed according to 7 criteria descriptive of their composition (Table 1.2, p.21). The number of elements making up the map (e.g. one image and one legend, or several images and one legend), the format, the orientation, presence or absence of a legend, the grid, the spatial cover and the mode of representation.

58% of the corpus is in portrait mode, but otherwise the format is the least relevant criterion. The average size of the figure contained between the ESPON blue bands is 163 mm*144 mm, or a mean area for the figure of 235 cm^2 (about 37% of a full page[9]). The format criterion is set aside in the rest of the analysis.

[8] This publication is a case apart; each figure corresponds to one map, which appears logical given the type of publication. Although, as noted, two of the Map of the Month issues did not present any map.
[9] An A4 sheet has a surface area of 623.7 cm^2

Two remarks can be made on the subject of the layout of the cartographic image before more detailed analysis of the corpus.They concern the place of the legend, and the presentation and wording of the titles.

8% of the maps have no legend. This low percentage (despite the fact that it can nevertheless appear too high) shows that ESPON maps generally attach importance to the relationship between image and legend, which is what enables the user to understand the intention of the developers. Another characteristic to observe is its positioning: 92% of the maps present the legend underneath the carographic image (Figure 1.8). Although this can be efficient for the organisation of a very complex legend, it is not at all suited to a simple map (loss of space, "drifting" information)

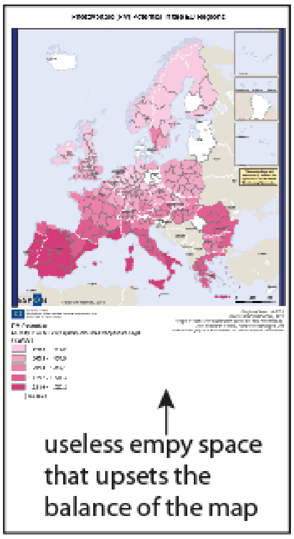
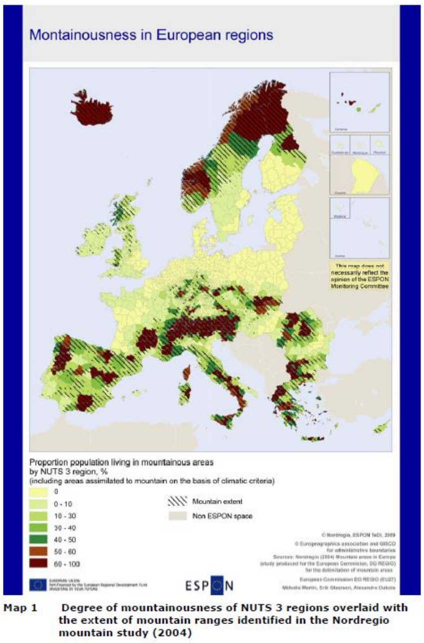


Figure 1.8 : Incorrect layout of map legend
Source: ReRisk P1 Project, 2010

The title is the element that generally serves as the gateway towards the subject matter of the map. Even the simplest title contributes to rapid comprehension, not only of the suject matter, but also of the political or scientific orientation chosen by the author to approach that subject. Whether it is a representation of a simple ordered or qualitative dimension (population, GDP or simple typology) or the representation of more complex results, the title of the map should always be explicit, avoiding unnecessary details and repeats in the legend title (note that the title of the map is different from the title of the legend). However the analysis of the corpus shows that in 197 figures, i.e. 38%, the index title and the title of the map are the same. In the example reproduced in Figure 1.9 and 1.10, it is correct to have a legend title that is different from the image title; here they are complementary and do not duplicate information. However the index title for its part complicates the task of assimilation of the message because it provides a lot of non-useful information which would have been better positioned in a footnote.



Main title: *Montainousness in European regions*

Index title: *Map 1 Degree of mountainousness of NUTS 3 regions overlaid with the extent of mountain ranges identified in the Nordregio mountain study (2004)*

Legend title: Proportion population living in mountainous areas by NUTS 3 regions, % (including areas assimilated to mountain on the basis of climatic criteria)

Figure 1.9: Incorrect matching of titles
Source: TeDi P2 Project, 2011

Finally, we note numerous duplicates thoughout the map corpus. 60 figures in the corpus are published two, three or four times. They are either identical, or in some cases with small differences – a change in title, the legend reads in a different order, the legend title changes.

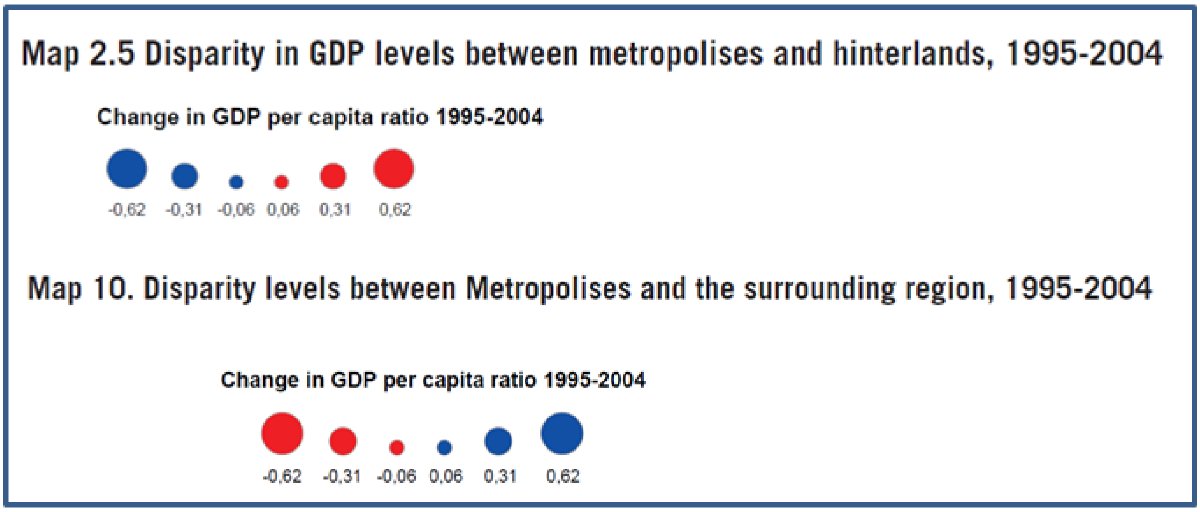


Figure 1.10 : Same map, 2 titles and 2 legends
Source: FOCI P1 project 2010, Synthesis Report p. 42et Scientific Report p. 21

Figure 1.11 gives an example of 4 maps published in 4 different documents – 4 titles for 4 identical maps.

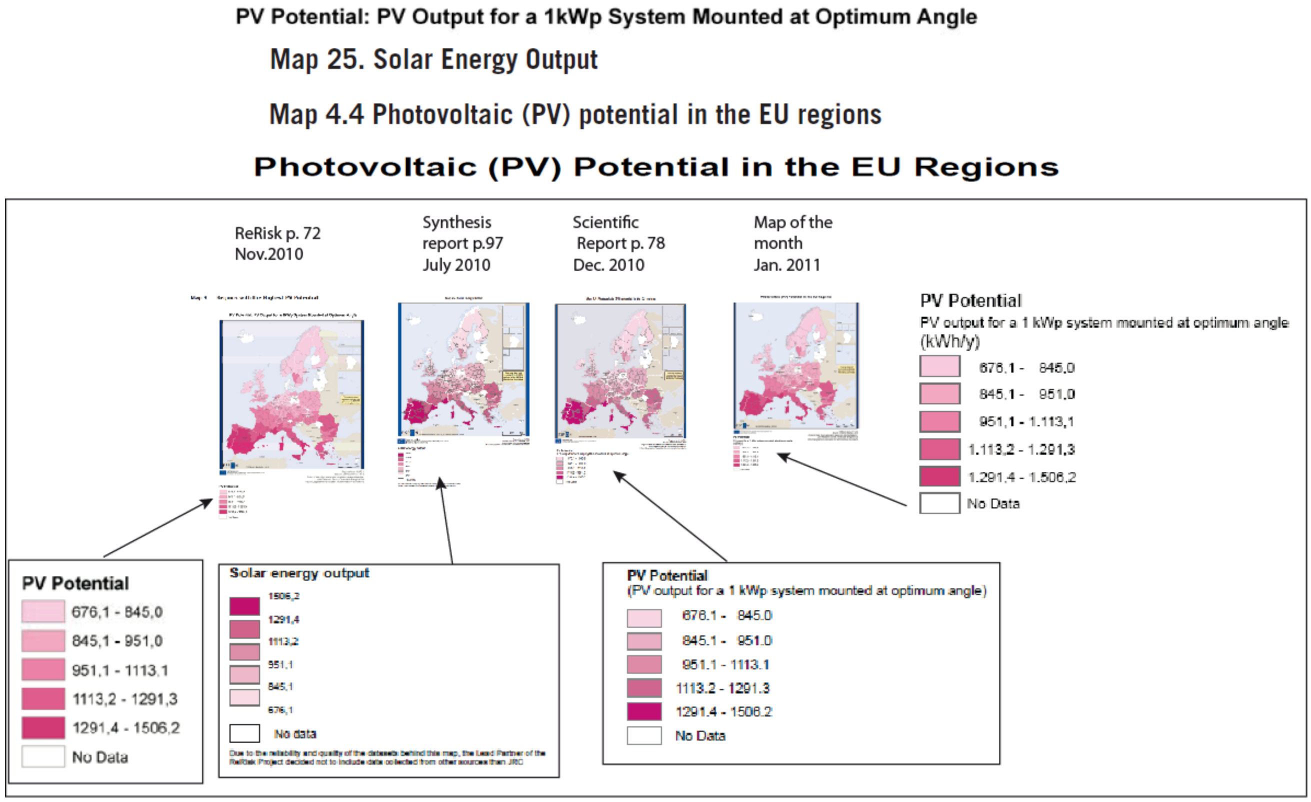


Figure 1.11 : Same map, 4 titles, 4 legends
Source: ReRisk P1 Project, 2010

All in all, three criteria provide the finest description of the corpus (Table 1.2) and enable an evaluatuion of the modes of representation used in the projects in relation to the type of data: spatial cover, territorial division and mode of representation.

Map Combinations	Single map
	Multiple map
Size	Length
	Width
	Surface
Legend	Yes
	No
Orientation	Portrait
	Landscape
Spatial Units	NUTS 0
	NUTS1
	NUTS2
	NUTS 2/3
	NUTS 3
	Cities
	States
	Grid
	Other
Spatial coverage	ESPON narrow (ESPON 3.1)
	ESPON wide (Europe +Turkey)
	Zoom in (local = less than Europe 27)
	Zoom out (macro région outside Europe)
	PanEuropean (Euromed)
	World
	Other
Cartographic representation	Choropleth ratio (areas)
	Chropleth typologies (areas)
	Graduated symbol maps (Points)
	Colored ratio graduated symbol maps (Points)
	Symbol typologies (Points)
	Grids (areas)
	Cartograms (areas)
	Smoothed maps (areas)
	Flows/Links (lines)
	Other

Table 1.2 : 6 categories for global description of the figures

2.1 Spatial coverage and geographic framework

Spatial cover determines the area to be covered by the geographical objects used to carry geographical information. It contributes to efficient visualisation of the message of the map. Too wide a cover will entail a lot of empty space providing no information, and a tighter cover will generate a congested map. Thus the choice of a suitable projection can be essential.

The "ESPON SPACE" defined in the current program, is composed of all the Member States of the European Union (27 countries) plus Switzerland, Norway, Iceland and Liechtenstein. The projection is based on the ETRS-LAEA system: ETRS89 Lambert Azimuthal Equal Area Coordinate Reference System. This projection is the standard in Europe for pan-European statistical mapping at all scales. In particular, this projection is used by the European Environment Agency. Parameters: latitude of origin 52° N, longitude of origin 10° E, false northing 3 210 000.0 m, false easting 4 321 000.0 m. (EPSG code: 3035). It is referred to as ESPON Wide (Current ESPON projection).
The previous projections used the same ETRS89 Lambert Azimuthal Equal Area Coordinate Reference System parameters, and only the centre of the projection changes, producing a slight rotation and influence of the cover (Figure 1.12). It is referred to as ESPON Narrow (Old ESPON Projection).

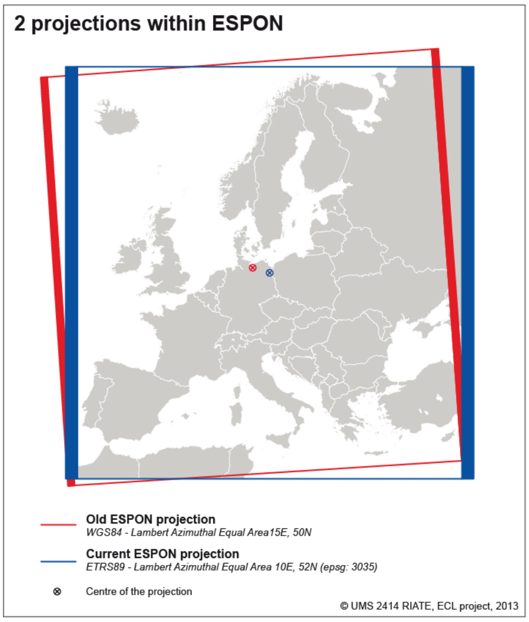


Figure 1.12:Former and current ESPON Projections

For each of the 762 maps in the corpus, we assessed their cover according to 7 scales of analysis: Europe ESPON Narrow, Europe ESPIN Wide (with Turkey and other candidate countries), the world using polar or pan-European projection, local scale (national or lower - City, FUA, LUZ etc) and others (very specific scales for a particular city for instance). Figure 1.13 shows a very marked predominance of images constructed on European scale (81%), among which 58% use the restricted scale of the ESPON Space. The local scale is used in only 12.4% of the maps.

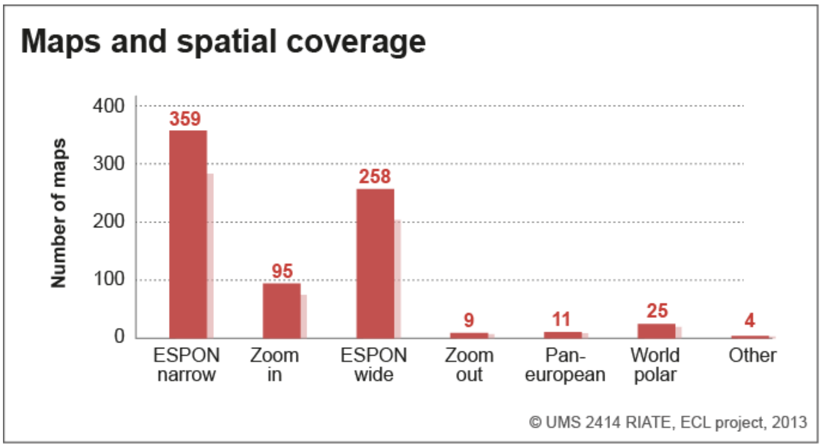


Figure 1.13 : Spatial Coverage used by ESPON Maps

2.2 Spatial Units

Another way to evaluate the use of scale is reference to the elementary units used by the maps, commonly known as the territorial divisions (spatial units) (Figure 1.14).

Five criteria are used here: the territorial unit nomenclature (NUTS, ranging from 0-3), the Local Administrative Unit (LAU), the grid, and the other types of unit. Figure 14 shows a clear predominance of representations using NUTS (80%) and particularly NUTS 2 or 3 (83% of all representations using NUTS). This choice tends towards very marked homogeneity of the general aspect of representations. 20% of the corpus use a different space division, most often according to cities (69%) or local representations (27.5%).

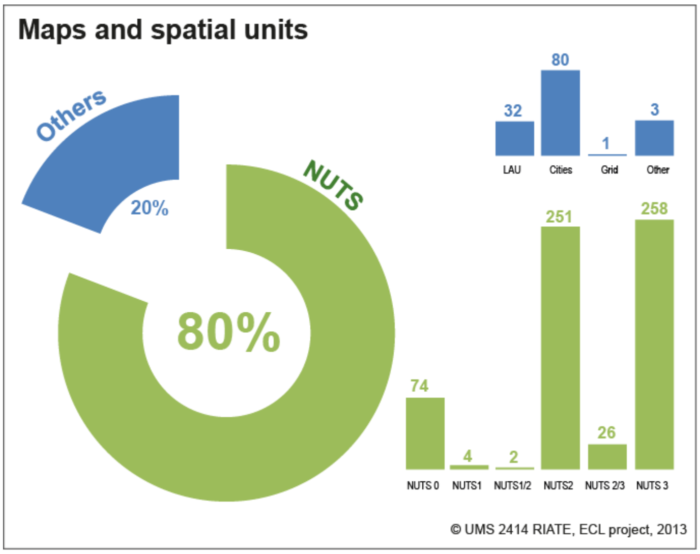


Figure 1.14 : Spatial Units used by ESPON Maps

2.3 Map Symbolisation

Cartographic representation, or map symbolisation, belongs to the field of graphic semiology. "A map is made to be looked at" (Brunet, 1987), to please and to attract. The task is to find ways to transform geographical information into a clear and effective visual message. The "message" borne by the map will only be effective if the choices in terms of graphic representations are made primarily in accordance with the purpose of the map and the nature of its readers. The "research" or "communication" objectives that may be assigned to a map necessarily generate very different graphic choices. The essence very probably resides in the ability of the map to show contrasts, specific forms, or particular phenomena, which will be retained in the memory of the reader. To achieve this, the cartographer needs to work on an accurate "translation" of the data (focusing on the nature of the data) and a suitable graphic symbol (choice of visual variables) on a particular territorial division.

To describe the modes of representation used in the ESPION programme, we determined 9 modes involving various mixes of the following: the nature of the data (ratios, raw data, typology), the nature of the geographical object considered (areal, line or point), and the type of symbolic representation chosen (choropleth, symbol, grid, cartogram, smoothing) : Ratio Choropleth (areas) ; Typology Choropleth (areas) ; Graduated Symbol maps (points) ; Colored Ratio Graduated Symbol maps (points) ; Typology symbols (points) ; Grids (areas) ; Cartograms (areas) ; Smoothed maps (areas) ; Flow-links (lines) and others.

Figure 1.15 shows a marked predominance of choropleth representations in the maps (68%), more or less equally divided between maps derived from ratio data (32%) and typology maps (ordered or otherwise) (36%). This results once again reflects great homogeneity in the general aspect of the maps in the ESPON corpus, and very little use of more original representations, such as cartograms (cartograms), representations of smooted data, or grids.

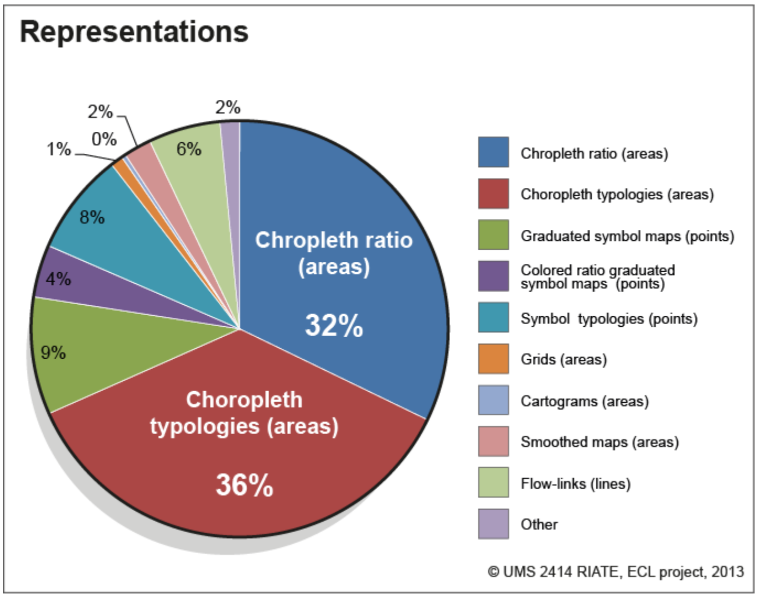


Figure 1.15 : Map symbolisation used for ESPON Maps

We also looked at how representations were combined (Figure 1.16). This measure enables an indirect approach to the issue of map complexity. A vast majority (79%) of the representations in the ESPON corpus are single maps with a single mode of representation). Only 21% of the maps combine 2 (17%), 3 (3.3% or 4 (0.7%) modes of representation.

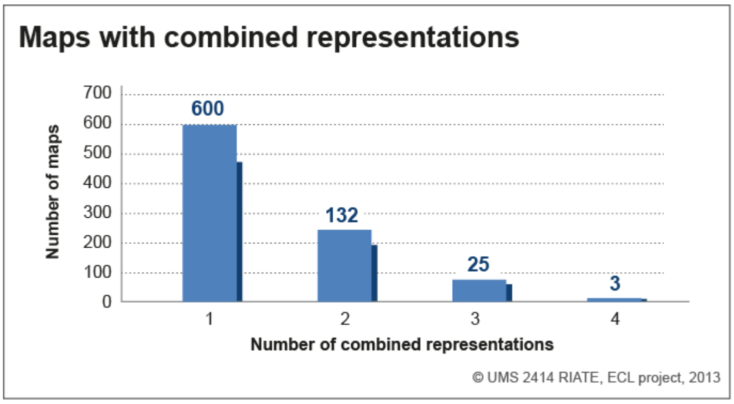


Figure 1.16 : Combined representations in ESPON Maps

Figure 1.17 gives a picture of these combinations. Cartograms and smoothed maps are not combined with any other mode of representation. Yet producing a cartogram readily allows for representation of raw data and ratios in the same image. Data flow maps are a mode of representation where combinations are fairly easy – maps frequently superimpose flows on choropleth data and/or stocks (point symbols). Finally, maps using proportional symbols (most often used for cities) tend markedly to appear in combination with graduated values represented by coloured areas.

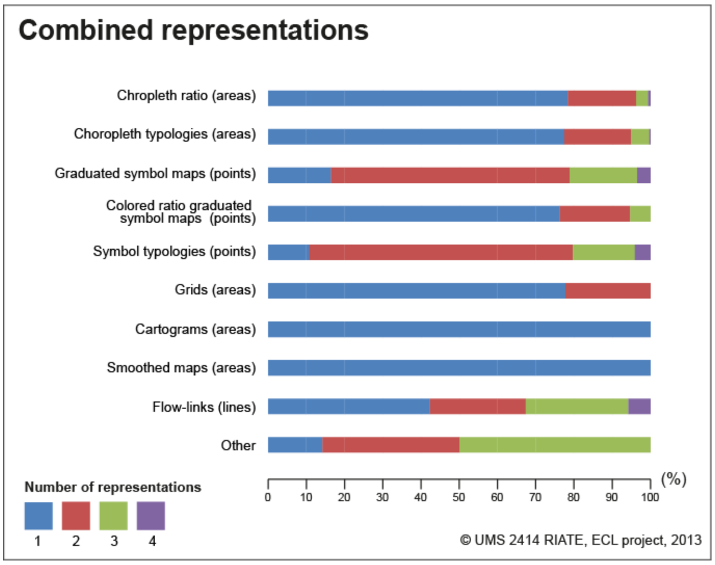


Figure 1.17 : Different types of combination for Map symbolization in ESPON Maps

The analysis can be further refined by more detailed examination of the possible combinations considered separately. Table 3 shows the combinations in maps using two different modes of representation. In the 10 modes retained here, 45 combinations are possible. Certain associations are predominant. The most common associations are between "typology choropleth" and "graduated symbol" (34 maps out of 122 use this combination). The association "ratio choropleth" and "Typology symbol" concerns 31 maps. The other associations concern only a few maps, often in the same report. This shows the original styles of the different projects.

Combined representations (x2)

	Chropleth ratio	Choropleth typologies	Graduated symbol	Colored ratio & graduated symbol	Symbol typologies	Grids	Cartograms	Smoothing	Flows - links	Other	
Chropleth ratio		5	8	6	31	0	0	0	2	2	54
Choropleth typologies	5		34	1	11	2	0	0	5	1	59
Graduated symbol	8	34		0	6	0	0	0	5	0	53
Colored ratio & graduated symbol	6	1	0		0	0	0	0	0	0	7
Symbol typologies	31	11	6	0		0	0	0	1	2	51
Grids	0	2	0	0	0		0	0	0	0	2
Cartograms	0	0	0	0	0	0		0	0	0	0
Smoothing	0	0	0	0	0	0	0		0	0	0
Flows - links	2	5	5	0	1	0	0	0		0	13
Other	2	1	0	0	2	0	0	0	0		5
	54	59	53	7	51	2	0	0	13	5	244

Table 1.3: Combination of two types of representations in ESPON Maps

3. Synthesis of the trends observed ESPON maps (main corpus)

In this section, we propose to summarize our previous observations in order to establish a general classification of the ESPON cartographic production. For this purpose, we have applied two complementary multivariate statistical analysis methods to the set of the 524 ESPON maps, described by 17 simple characteristics. Each characteristic is converted into a Boolean variable corresponding to the answers Yes=1 and No=0 for each of the characteristics. The difference between two maps in this type of table can be measured by Chi-square metrics, and a hierarchical clustering procedure (Ward Criteria) provides optimal visualization of similarities and differences between the maps in the sample. The examination of the classification tree demonstrates that we can clearly distinguish two main clusters of maps (type A and B), which can be further divided into 7 more detailed subtypes. The characteristics of the different types of maps can be examined either in an analytical way (Tab. 4) or in a synthetic way (Figure 1.18). Each type is also illustrated by a typical example (Figure 1.19)

17 indicators for Cluster Analysis

ESPON global corpus

		A1	A2	A3	B1	B2	B3	B4
	Number of maps	52	81	79	79	86	77	68
	% of maps	10%	16%	15%	15%	16%	15%	13%
COMBINATION	Single map	100%	100%	100%	61%	97%	66%	91%
	Multiple maps	0%	0%	0%	39%	3%	34%	9%
ORIENTATION	portrait (Vertical)	96%	95%	92%	76%	84%	73%	78%
	Lanscape (Horizontal)	4%	5%	8%	24%	16%	27%	22%
SPATIAL UNITS	States or groups of states	0%	0%	0%	1%	0%	1%	93%
	Macro-regions (NUTS2 or NUTS1-2)	100%	100%	0%	37%	58%	2%	1%
	Meso regions (NUTS3 or NUTS2-3)	0%	0%	100%	62%	42%	5%	1%
	Other (LAU1, LAU2, Cities, Grids, ...)	0%	0%	0%	0%	0%	97%	7%
SPATIAL COVERAGE	ESPON area (narrow)	100%	100%	100%	22%	57%	27%	34%
	ESPON area (wide)	0%	0%	0%	49%	0%	15%	22%
	Zoom in	0%	0%	0%	41%	43%	59%	12%
	Zoom out	0%	0%	0%	0%	0%	0%	41%
CARTOGRAPHIC REPRESENTATION	Areal (choropleth)	100%	100%	100%	100%	74%	51%	66%
	Punctual (dot)	0%	0%	0%	4%	88%	47%	37%
	Other (grids, networks, limits, ...)	0%	0%	0%	0%	22%	43%	26%
INDICATOR REPRESENTED	Relative Indicators (ratio)	100%	0%	66%	51%	31%	29%	37%
	Absolute Indicators (size)	0%	0%	0%	0%	69%	36%	24%
	Typology (Categories)	0%	100%	37%	52%	71%	47%	47%

Table 1.4: Properties of the seven types of ESPON maps

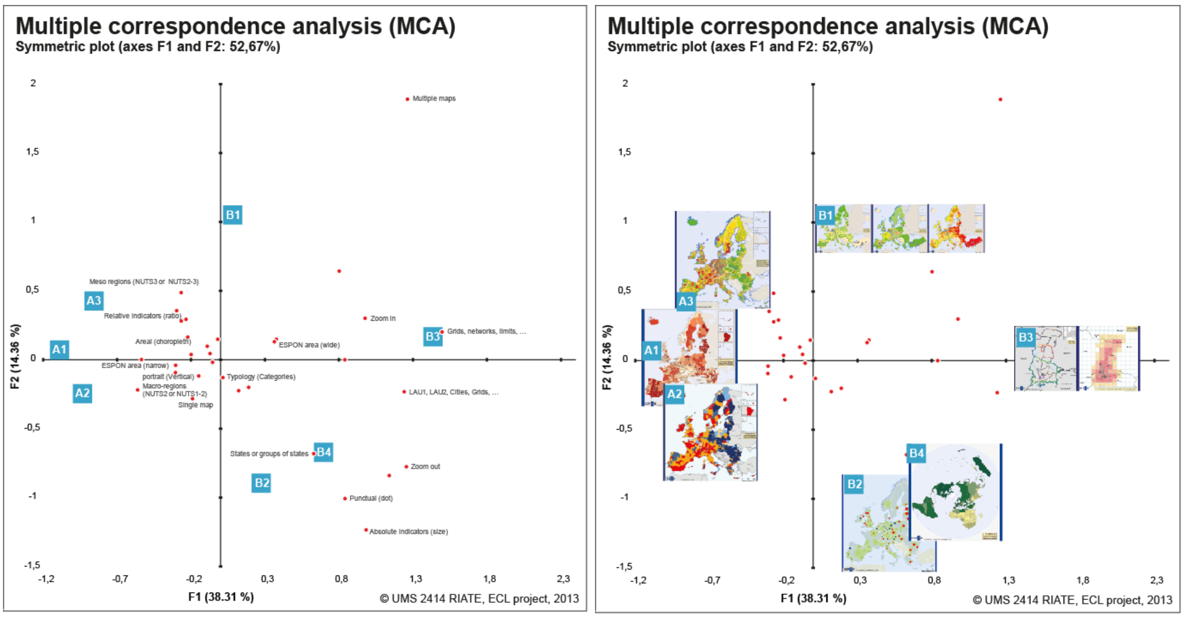


Figure 1.18: Synthetic representation of 7 types of ESPON maps

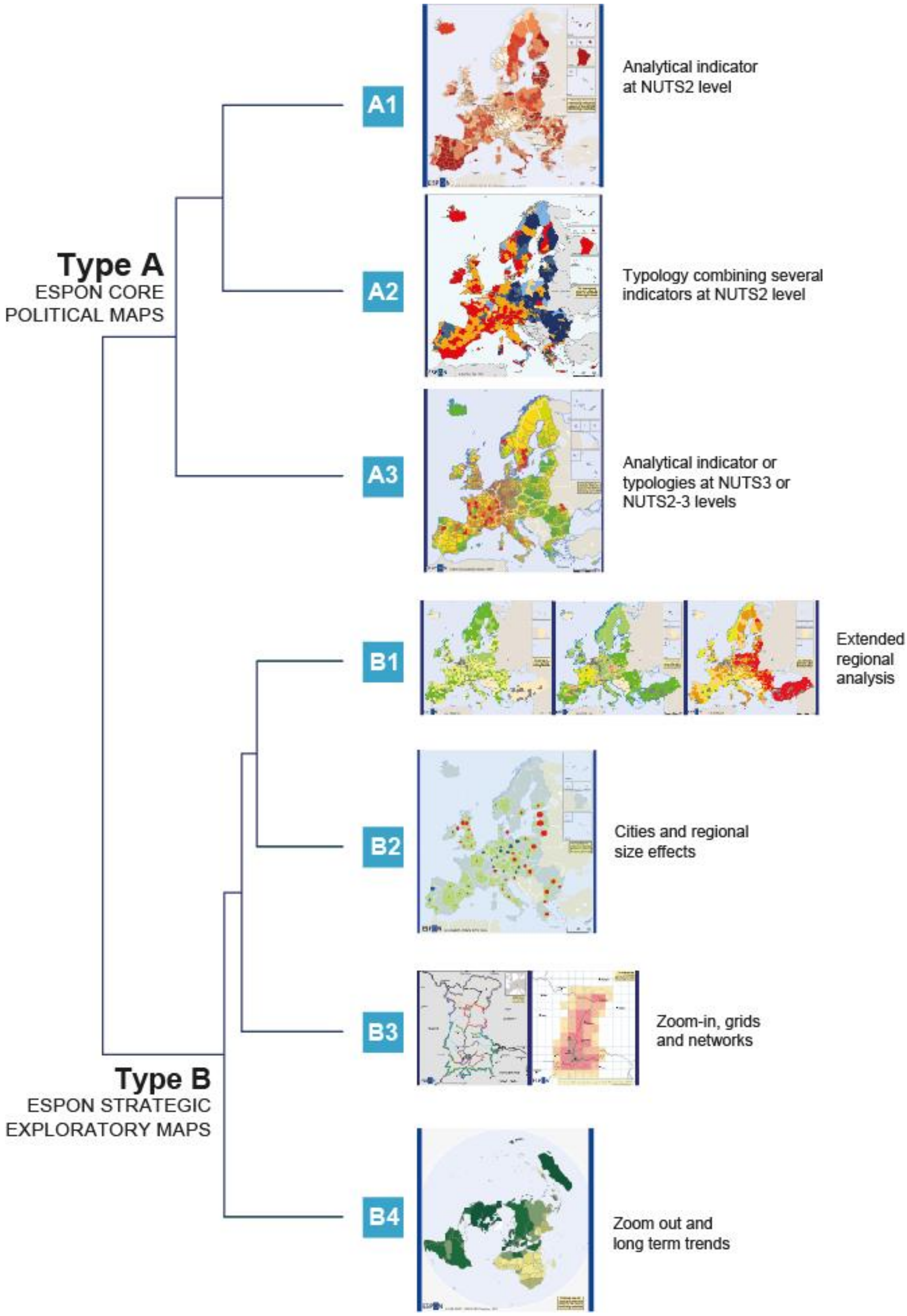


Figure 1.19: Map types from cluster analysis and typical examples

Type A: ESPON CORE POLITICAL MAPS

The ESPON Core Political maps represent 41% of our sample. They are characterized by a set of common characteristics that defines a very homogeneous group:

- *Areal representation of regional indicators*: the core maps focus on the presentation of indicators that are independent from the size of units. The cartographic magnitude of regional units is proportional to their area.
- *Maps vertically oriented, covering only ESPON3.1 but not neighbouring or candidate countries*: the core maps exclude information that is not of direct interest for EU policy, and adopt the cartographic template used by DG Regio or Eurostat.
- *Simple maps with simple message*: only one indicator is presented on each map and no comparison is possible.

Besides these general characteristics, three different subtypes can be identified, corresponding to different uses of maps by policy makers.

Type A.1: Analytical indicator at NUTS2 level : Whatever the criteria, the objective of the map is to present quantitative variations on a continuous scale, making it possible to distinguish the regions with high or low values on a single scale. The figures can be measured in their original unit of measurement, or normalized with an index 100 equal to EU27 or ESPON31 average. We recognize here the typical style of Eurostat or DG Regio maps.

Type A.2: Typology combining several indicators at NUTS2 level: A set of criteria describing NUTS2 regions is summarized by a single map with qualitative differences. In the majority of cases, the typology is the result of the combination of only 2 analytical criteria, A and B, with a differentiation based on their respective levels ("A low & B low", "A low and B high", "A high and B low", "A high and B high"). But it can also be the result of a synthetic index (average sum of standard values of A, B, C, etc., with appropriate signs) and sometimes – but in a minority of cases – the result of a clustering method that does not necessarily imply a hierarchy, as in the case of a synthetic index. Typology maps at NUTS2 level are without any doubt a main characteristic of the "ESPON brand", if we consider the number of posters, maps of the month or maps in the synthesis reports that belong to this type.

Type A.3: Analytical indicator or typologies at NUTS3 or NUTS2-3 levels: This group of maps is identical to the two previous groups, the only important difference being that the regional units provide more details because they are smaller. We can say that the spirit of this group of maps is more "OECD-oriented" as it does not try to stick exactly to the NUTS2 level used for Structural Funds allocation. The maps in this group are therefore less interesting for strategic planning, and less relevant for short-term decisions in the EU agenda.

Type B: ESPON STRATEGIC EXPLORATORY MAPS

The ESPON strategic exploratory maps can be defined negatively as those that do not belong to the previous group of ESPON core maps. This group is indeed very heterogeneous and corresponds to a different research strategy, which has been developed by ESPON in order to meet long-term political objectives of territorial cohesion, rather than short-term demands for information related to structural funds. We can basically distinguish four different types of maps, corresponding to different paths of development in the ESPON program.

***Type B.1: Extended regional analysis*:** These maps remain focused on the regional level (NUTS2 or NUTS3) but with a wider geographic extension than the group of core maps. They frequently include the candidate countries and the immediate neighbouring areas, and they can in some cases propose a zoom-in on selected territories. They can combine different maps in the same figure, in this case adopting a landscape (horizontal) rather than portrait (vertical) orientation. But they remain very similar to the Core Group in terms of cartographic and statistical choices because they always used an areal representation of single indicators or typologies. Size effects are never introduced.

Type B.2: Cities and regional size effects: These maps generally use a point representation whereby territorial units of different types (regions but also cities) can be compared not only in terms of levels or type, but also in terms of size. It is very likely that a regional map of this type will use circle representations (defining for example the population of a region within size of a circle) which are coloured (defining a typology) or shaded (defining the level of an indicator). The reader of the map is therefore invited to explore the relationship between the size of units and other criteria of interest. This is of course especially interesting when the spatial units are cities rather than regions. In this case, size alone can be the criterion of interest (e.g. number of headquarters of firms in a FUA)

Type B.3: Zoom-in, grids and networks: This group of maps is very different from the previous one by the choice of the territorial units, which offer more detail on local distribution. Here we typically find the “Zoom in” maps produced by Priority 2 projects or by case-studies performed in Priority 1. But accessibility or natural hazard maps using grid or network data belong also to this group of maps which do not use the official regional units of NUTS2 or NUTS3 levels. In many cases, different maps are combined in the same figure and/or different types of cartography are combined in the same map. It is typically here that very original productions can be observed providing policy makers with precious information on phenomena, even if this information is not directly related to regional policy.

Type B.4: Zoom-out and long term trends. This very specific group is characterized by the use of NUTS0 units (states) and by the frequent choice of much wider areas than ESPON31 (world, neighbouring countries, etc.). These maps are clearly less precise in terms of spatial resolution, but they offer a more global view of trends and evolutions because the time series are generally more complete and longer at state level. These maps are not limited to areal information (states) and they can combine information on nodes (world cities), networks and flows. The reduction of spatial detail is clearly counterbalanced by much greater scope for crossing phenomena of different types at different periods of times.

4. Detailed analysis of a selection of maps

We chose to perform a second selection to extract a new corpus of maps for more detailed analysis of their conception. This new corpus concerned about 10% of the total map corpus from the ESPON 2013 programme.

4.1 Analysis of a selected corpus

In order for this new corpus to be meaningful in relation to the ESPON 2013 programme, several principles were used to guide the selection:
- 1st round of selection: we selected all the maps highlighted by ESPON (Map of the Month, Territorial Observation, Synthesis Report, Scientific Report) and the TPG Executive Summaries. This oprovided a corpus of 91 maps. However this selection was still not satisfactory, since it excluded *de facto* those maps that could be described as original in design or content.

- Therfore, in very subjective manner, we then selected maps that did not appear in the first selection round and that seemed to us to be worth analysing, for scientific reasons, and for the context of their publication for example: cartograms, grids, ESPON 3.2 and ESPON Atlas. This added 28 maps to the new map corpus.

- Finally the maps were sorted and grouped to avoid excessive redundancies in the modes of representation or types of map (type of base map, type of generalisation, type of grid etc) while at the same time preserving the diversity of the spaces represented, the modes of representation implemented, and the variety of the subject matter.

The final reduced corpus for finer analysis of representation choices, whether in terms of conception (links with graphic semiology) or implementation, comprises 59 maps. A new study strategy was used so as to focus on a few particular issues:
- the complexity of the map
- the complexity of the phenomenon represented
- the intelligibility of the map
- the effectiveness of the map in communicating the political message.

The strategy presented in Table 5 is organised according to 5 criteria. A set of items enables identification of the map analysed within the overall corpus. Three criteria (base map features, data and semiology) then enable a breakdown of the processes of map design into 17 items. What is the spatial cover, and what type of projection is used? What data is used and what is its nature? How is the data represented? What graphic semiology is used, and what visual variables? What visual variables are used for what data? What relationship is there between the data and the administrative subdivision used?

Finally, one analysis criterion of the effectiveness of the map is approached via 9 assessment items: the complexity of the phenomenon, the existence of clear patterns of spatial organisation, satisfactory coherence between base map and the subject matter and/or the indicators used, the choice of appropriate graphic semiology, its effectiveness in representing the phenomenon, the management of the complexity of the legend with respect to cartographic composition, the quality of the base map, the comprehension of the phenomena respresented on the map, and the aesthetic qualities of the map. This set of items enables a subjective score to be attributed to the different elements involved in the design and production of a map. A range of scores from 1 (poor) to 5 (good, or clear) is applied for each of the 9 items. Scores are then summed to obtain a global score for the effectiveness of the map.

Categories	Description	Aim
MAP IDENTIFICATION	Map ID	Locating the map in the corpus
	Figure ID (in the full corpus)	
	Report name	
	Date	
	Filename	
BASE MAP FEATURES	Spatial coverage	Analysis of the base map that determines the spatial cover of the map
	Spatial division	
	Map Projection	
	Cartographic generalization	
	Scale	
	Zoom box	
	Remote areas	
DATA	Data identification	Data analysis/ Types of data and source / Links with data base
	Data types	
	Data source	
	Data processing	
SEMIOLOGY	Territrorial object (points/lines/areas)	What semiology, what type of representation?
	Figuration	
	Visual variables used	
	Number of visual variables	
	Type of cartographic representation	
EFFECTIVENESS of the MAP	Complexity of the phenomenon displayed on maps	More subjective analysis of the effectiveness of the map, its comprehensibility, the link between message and representation, and general appreciation of map quality. Scores are allocated from 1 (poor) to 5 (good, clear, simple). The sum of the scores gives the global appreciation.
	Implementation of a spatial pattern (maup pb)	
	Mapkit choice	
	Choice of the graphic semiology	
	Efficiency of graphic semiology	
	Structuration of legend	
	Appropriate base map (generalisation)	
	Intelligibility of the map in 10 s	
	Aesthetic qualities	
	Global appreciation (aesthetics, effectiveness, comprehensibility)	

Table 1.5: Detailed analysis for 59 maps of ESPON production

4.2 Average score for effectiveness of ESPON maps

The detailed analysis of this final corpus enabled precise exploration of each of the maps selected. The purpose of this process was to more precisely apprehend which different elements contribute to producing a representation of the phenomenon that is at once effective and aesthetic. This analysis grid needs to be completed by an exploration of links between the subject matter, the production of the map, and its effectiveness among political decision-makers and technicians in the particular field.

The scoring process proves to be very subjective, despite the fact that it took place under homogeneous assessment conditions[10]. It nevertheless enables several issues to be pinpointed in relation to the synthesis on the global corpus set out on page 26.

Visual variables

Six visual variables can be involved, depending on the graphic semiology. They enable representation on a map of quantitative or qualitative, ordered or differential phenomena. There should therefore always be a link between the nature of the data, its materialisation (point, line or zone) and its representation: "The visual variables serve to guide basic map symbol design" (Krygier J, Wood D, 2011, p.176). Figure 1.20 sums up these links.

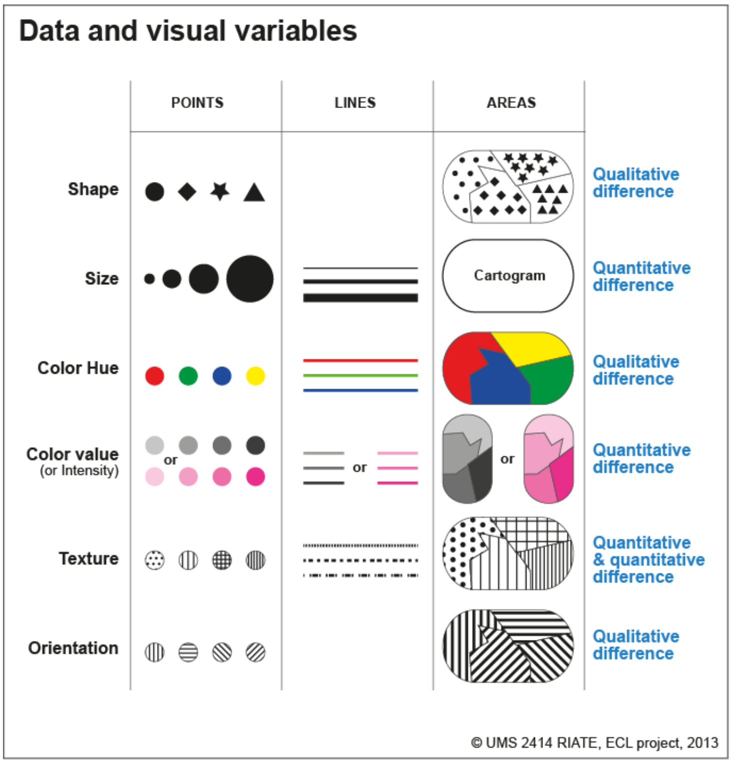


Figure 1.20: Matching Data to Visual Variables

Overall the link between the visual variables used and the type of data is complied with (with the exception of 4% of the cases). This link leads to good scores on the graphic semiology items for the corpus.

The number of visual variables used reflects another dimension that is the degree of complexity of the representation. When a single visual variable is used, the map can be considered to be simple and easy to access. 22 maps of the 59 analysed prove to be very simple maps. One example of this group of maps is given in Figure 1.21.

[10] 5 individuals took part in this scoring procedure

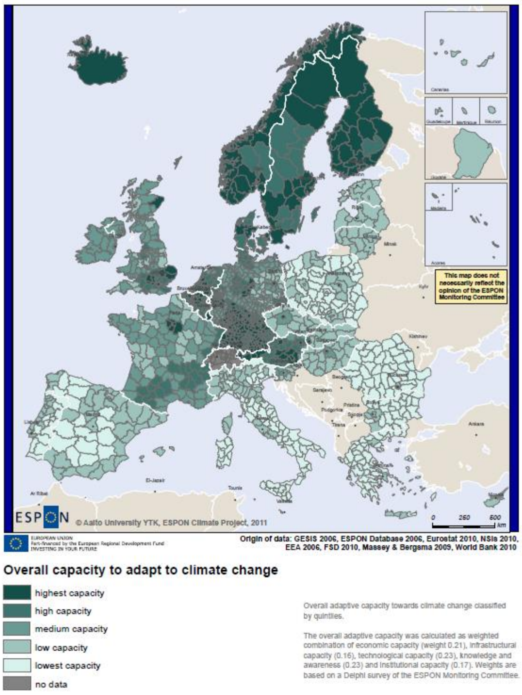


Figure 1.21: Use of a single Visual Variable (Color Intensity)
Source: P1 ESPON Project, ESPON Climate, Final Report, p.21

On average, 1.91 visual variables are used per map. We can again conclude that ESPON maps tend to be simple. There are a few exceptions (Figure 1.22) mixing visual variables and presenting so-called "synthesis" maps, which prove to be very complex and not very suitable for political or operational usage.

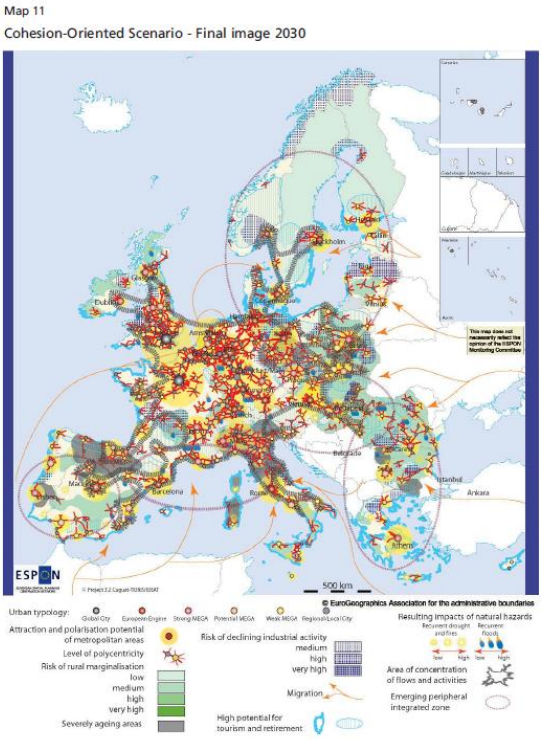


Figure 1.22: A complex image with 5 visual variables used together
Source: ESPON Project 3.2 Scenarios on the territorial future of Europe, p.51, Final image 2030

Projection/layout/ base map

With the exception of specific projections (local, world) the projections used subdivide into two categories: old and new ESPON Projection (See previous figure 1.12, p.17). The majority of the maps do not comply with the projection established by the ESPON 2013 *mapkit*.

The base map used is systematically the Eurographics base. This base map is well suited to the presentation of detail on a large scale, but in the example below (Figure 1.23) given the representations involved and the map format, this generalisation is clearly damaging for the aesthetic aspect and the effectiveness of the map. The over-precise outlines emphasise the boundaries, traced in black, thus obscuring the scientific and political intention of the map.

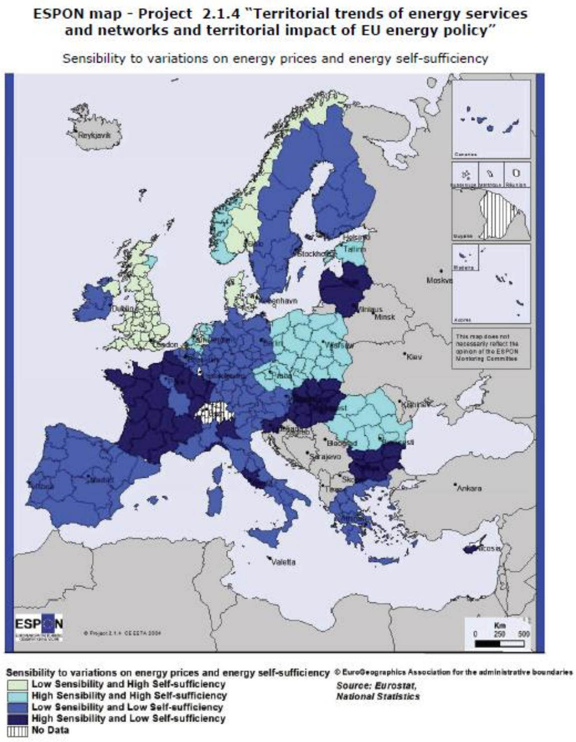


Figure 1.23: Over-precise outlines damage the scientific message
Source: ESPON Project Maps of the month, October 2008

Map effectiveness

Cartographic production, to be effective, requires careful balancing of simplicity in the modes of representation, judicious use of graphic semiology, and the organisation of modes of representation and layout. The map can and should provide a narrative, even if it is straightforward. The narrative is effective if the link between what is perceived visually and the apprehension of the subject matter occurs as immediately as possible.

The following map (Figure 1.24) gives simple information on an evaluation of pollution linked to transport and its impact. The three-stage legend requires zonal, hierarchical semiology which is complied with. However a qualitative mode is added, the "flagging" of regions, focusing on the regions that will be most affected according to a future challenge scenario in the analysis, using a base map that is not well suited because it is insufficiently generalised given the scale of representation. This is very damaging both in terms of rapid comprehensibility of a clear message, and in aesthetic terms. The flags are too black and too large, hindering the perception of the coloured areas. Some of the smaller flags do not appear to have their place in the general message.

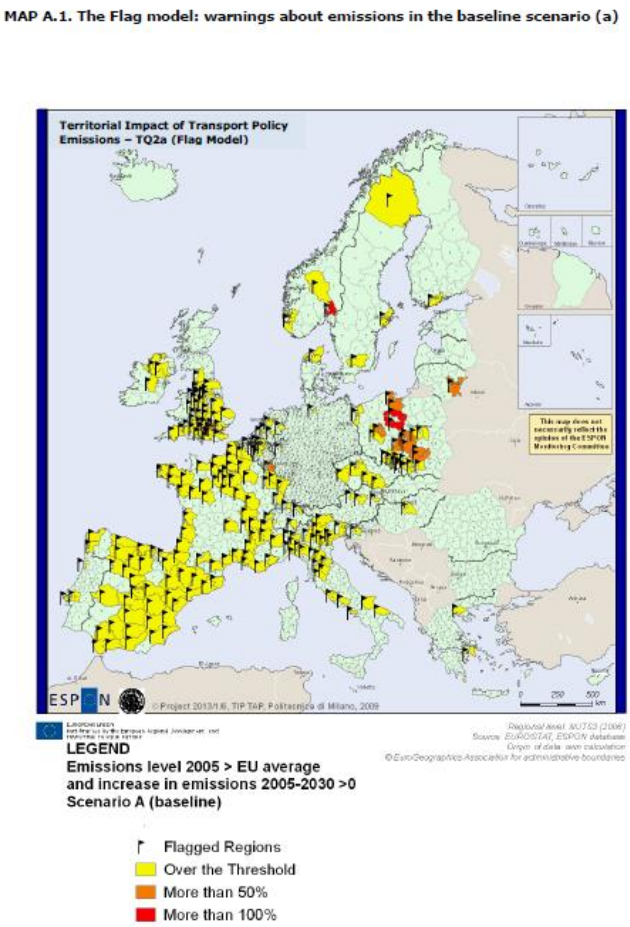


Figure 1.24: Cartographic Symbolization and comprehensibility of the message
Source: ESPON P1 Project, TIP TAP, The Flag model scenario, Maps of the month, March 2010

In the next example (Figure 1.25), the semiology is poor. The proportional circles cannot be compared and are illegible. There is too much detail on this map, which aims to show the numbers of partners in INTERREG IIIb projects (there is no legend to enable appreciation of these numbers) and it uses a different colour for each partner. The map is crowded; it takes a long time to decide what it is trying to say. The map does not achieve the objective of simplified communication of information.

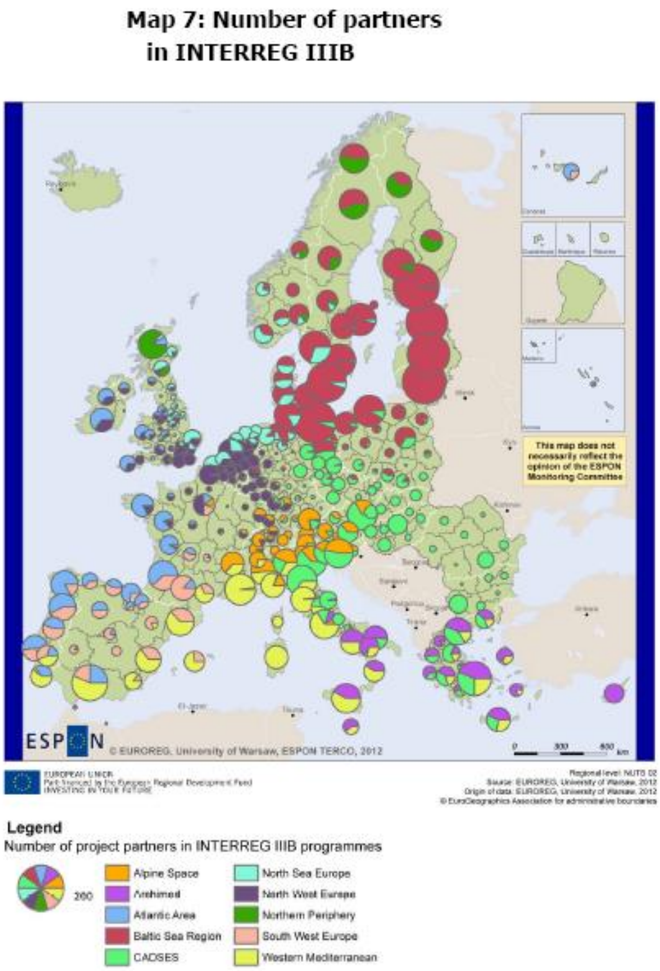


Figure 1.25: Crowded symbolization and lack of effectiveness of the map
Source:

This complexity could be represented by straightforward compilation if it remains comprehensible, or by processing the data upstream in order to summarise its complexity. A map is always a simplification of a complex reality. Prior data processing is often the best option, even if this may require provision of a detailed legend. Figure 1.26 shows two ways of mapping complexity. The map on right uses lot of visual variables in order to translate geographical information in the representation and chooses to display them all together. Instead, the map on left chooses to transform the data before its representation and to display it on a simple map using one visual variable (colour shade). It is visually simple but requires more reflection in the understanding of the legend that is organized as a second page.

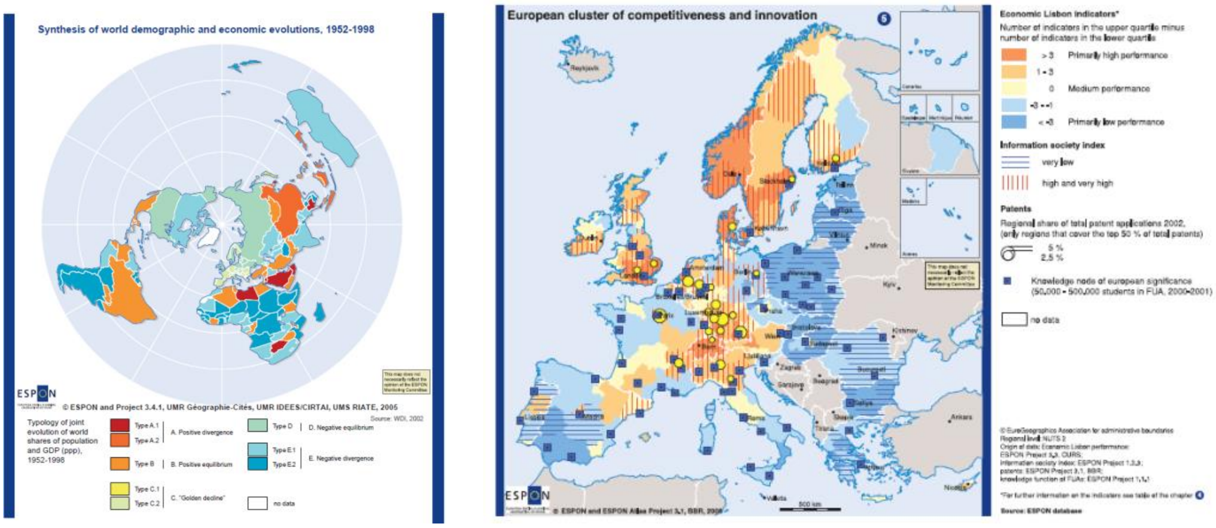


Figure 1.26: Upstream data processing versus compilation: managing the complexity of a phenomenon
Source: ESPON 3.1, 2005 (left) & ESPON Atlas Project, BBR, 2008(right)

CONCLUSION TASK 1: Weaknesses and Strengths of ESPON Cartographic production

The analysis of the ESPON Corpus has established a general classification for the ESPON cartographic production. We have also pointed out some particular cartographic issues concerning the effectiveness and the complexity of ESPON Cartographic language. In conclusion, remarks fall into two categories: weaknesses and strengths of ESPON Cartographic production.

- **Evidences**

- 80% of the ESPON maps are designed on NUTS nomenclature
- 87% of figures can comprise a single illustration
- 79% of ESPON maps use a unique semiotic representation
- 68 % are choropleth maps
- 81% of maps are images constructed on European scale among which 55% use the restricted scale of the ESPON Space

- **Weaknesses**

- Without the text, many of the maps would not be easy to understand : they require better contextualisation and better legends;
- Little originality, with a lot of elementary productions and too much standardisation (blue lines, base maps, colours, title, legend, orientation, sources....);
- Marked typological homogeneity among maps;
- No marked interest in the aesthetic qualities of a map;
- Reflection on cartographic issues is often lacking;
- Little innovative production; there are however a few original features. Figure 1.27 is a striking example of a degree of originality;
- Layout is never designed in relation with the map message.

- **Strengths**

- Strong visual identity ;
- No major mistakes in the use of graphic semiology;
- Transfer of the data to the map generally well managed;
- Data correctly identified.

Figure 4 Increase in mean annual temperature plotted on a population cartogram

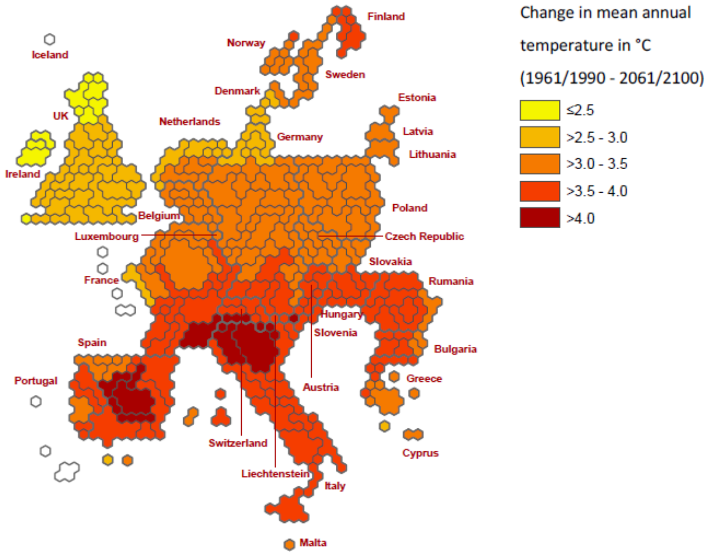


Figure 1.27: One original production
Source: ESPON DEMIFER project- Priority 1 Final Report p. 72

Map References Task 1

References of all the maps included in the ESPON corpus (Selection 2).

ESPON Report	Page number	Date	Title of the figure
ARTS	49	May 2011	Regions affected by Directive on managing environmemental noise branch b Number of people exposed to noise (F25)
ATTREG_FR	58	April 2012	Figure 11: Regional typology by types of flows attracted
ATTREG_FR	60	April 2012	Figure 12: Regional typology by retentiveness of age cohorts
ATTREG_FR	69	April 2012	Figure 14: Differences between predicted and observed membership of visiting-migration typology
BEST METROPOLISES	6	January 2013	Map 1 Functional Urban Areas of Paris, Berlin and Warsaw
BEST METROPOLISES	12	January 2013	Map 2 Change of demographic structures in the Paris, Berlin and Warsaw metropolitan areas
BEST METROPOLISES	41	January 2013	Map 4 Commuting flows between NUTS 3 (Paris and Berlin) and LAU 1 (Warsaw)
DATABASE	45	March 2011	Figure 2.5.1 - Active people 2006 in agricultural grid cells (CLC 2006)
DEMIFER	50	September 2010	Figure 4 Increase in mean annual temperature plotted on a population cartogram
EDORA	VI	August 2011	Map E1: The Three EDORA Typologies
ESPON ATLAS	66	October 2006	Median age situation 2000-2015-2030
ESPON ATLAS	35	October 2006	The core and the periphery
ESPON ATLAS	44	October 2006	Cultural employment and GDP
ESPON ATLAS	31	October 2006	MEGAs & competitiveness
ESPON ATLAS	37	October 2006	Accessibility vs. Economic performance
ESPON CLIMATE	19	May 2011	Map 18: Aggregate potential impact of climate change
ESPON CLIMATE	24	May 2011	Map 20: Potential vulnerability of European regions to climate change
ESPON CLIMATE	21	May 2011	Map 19: Adaptive capacity of European regions in regard to climate change
FOCI	26	December 2010	Figure 1. Typology of intra-urban dynamics in European LUZ, in the years 2000
FOCI	41	December 2010	Figures 7. Position of European cities as intercontinental (a) gatekeepers, (b) representatives and © platforms
FOCI	47	December 2010	Figure 9. Change of disparities in the development level between the metropolis and its regional hinterland in 1995-2004
FOCI	11	December 2010	City network contactability by rail between MEGAs. Return trips between 5h and 23h
Map of the month		2009	Potential accessibility by air 2001-2006

ESPON Report	Page number	Date	Title of the figure
Map of the month		September 2011	European Regions 2010: Economic Welfare and Unemployment
Map of the month		2009	GDP-PPS per capita in 2006 versus potential accessibility (multimodal) in 2006
Map of the month		2008	Population development by components for 2001-2005
Map of the month		2004	Sensibility to variations on energy prices and energy self-sufficiency
Map of the month		2005	Origin of migrants in EU27 + 2 according to their country of birth, 2000
Map of the month		January 2001	Photovoltaic (PV) Potential in the EU Regions
Map of the month		February 2013	Number of women per 100 men in the age group 25 to 29 in 2008
Map of the month		March 2010	MAP A.1. The Flag model: warnings about emissions in the baseline scenario (a)
Map of the month		March 2011	MAP A.2. The Flag model: warnings about emissions in the infrastructure scenario (b)
Map of the month		March 2012	MAP A.3. The Flag model: warnings about emissions in the pricing scenario (c)
Map of the month		November 2009	Performance of Less Accessible Regions
Map of the month		January 2012	Aggregate potential impact of climate change
Map of the month		January 2013	Potential vulnerability to climate change
Map of the month		January 2014	Wind Power Potential
Map of the month		2006	World trade, 1996-2000
Map of the month		May 2011	Households using a high-speed Internet connection, average percentage over the years 2006 to 20009
Map of the month		May 2012	IP addresses per capita, 2009
Map of the month		2005	Synthesis of world demographic and economic evolutions, 1952-1998
Map of the month		January 2010	Economic Performance of European Regions, 2006
Map of the month		2006	Population in EU and its neighbourhood in 2030
Map of the month		October 2012	Map 11 - Regional typology by types of flows attracted (4 classes), 2001-07
Map of the month		July 2012	Evolution of cities servicing global capital, 2000-2008
METROBORDER	20	December 2010	Map 4 The Functional Urban Areas (FUAs) of the CBPMRs
METROBORDER	67	December 2010	Map 19 'CBPMR Greater Region': schematic synthesis map of METROBORDER results
METROBORDER	70	December 2010	Map 20 'CBPMR Upper Rhine': schematic synthesis map of METROBORDER results
METROBORDER	55	December 2010	Map 15 left: cross-border institutions and their perimeter within the Upper Rhine region
POLYCE	13	May 2012	Map 1: Research networks between POLYCE metropolises (2001-2010)
Scénario 3.2	10	May 2007	Cartograms showing size of regions in terms of population (left) and GDP (right)
Scénario 3.2	27	May 2007	Map 7 Spatial structure and urban hierachy in 2030 according to the Trend Scenario
Scénario 3.2	60	May 2007	Map 15 Roll Back Proactive Scenario - Image 2030
Scénario 3.2	51	May 2007	Map 11 Cohesion-Oriented Scenario - Final image 2030

ESPON Report	Page number	Date	Title of the figure
SCIENTIFIC REPORT	14	Decembre 2010	Map 2.1 GDP per capita in European cities, 2006
SCIENTIFIC REPORT	31	Decembre 2010	Map 2.10 Roles of European cities as continental functional areas
SCIENTIFIC REPORT	32	Decembre 2010	Map 2.11 City links in multinational fi rm networks
SCIENTIFIC REPORT	49	Decembre 2010	Map 3.1 The Dijkstra-Poelman urban-rural typology
SCIENTIFIC REPORT	50	Decembre 2010	Map 3.2 The structural typology of rural regions
SCIENTIFIC REPORT	51	Decembre 2010	Map 3.3 The performance typology of rural regions
SCIENTIFIC REPORT	54	Decembre 2010	Map 3.4 The EDORA exemplar regions
SCIENTIFIC REPORT	71	Decembre 2010	Map 4.1 Regional GVA in industries with high energy costs, 2005
SCIENTIFIC REPORT	74	Decembre 2010	Map 4.2 Long-term unemployment in the regions, 2007
SCIENTIFIC REPORT	76	Decembre 2010	Map 4.3 Mean maximum temperature for July
SCIENTIFIC REPORT	78	Decembre 2010	Map 4.4 Photovoltaic (PV) potential in the EU regions
SCIENTIFIC REPORT	15	Decembre 2010	Map 2.2 Disparity in unemployment rates between low qualifi ed persons and city averages, 2006
SCIENTIFIC REPORT	81	Decembre 2010	Map 4.5 Regional typologies of energy poverty
SCIENTIFIC REPORT	17	Decembre 2010	Map 2.3 Disparity in population growth between suburbs and core areas of cities, 2000-2006
SCIENTIFIC REPORT	18	Decembre 2010	Map 2.4 Weighted variance in unemployment rates by city districts, 2000
SCIENTIFIC REPORT	21	Decembre 2010	Map 2.5 Disparity in GDP levels between metropolises and hinterlands, 1995-2004
SCIENTIFIC REPORT	22	Decembre 2010	Map 2.6 Typology of metropolitan macroregions
SCIENTIFIC REPORT	25	Decembre 2010	Map 2.7 Functional differentiation in urban networks, 2006
SCIENTIFIC REPORT	27	Decembre 2010	Map 2.8 City network contactability by rail and/or air, 2009
SCIENTIFIC REPORT	28	Decembre 2010	Map 2.9 City network contactability by rail, 2009
SGPTD	7	June 2012	Map 2.1: The 31 Capital and 124 Second tier cities in this study
Synthesis Report	15 & 16	January 2010	Map 1. Illustrating the Multi-Level Approach: The example of population growth, 2001-2006
Synthesis Report	42	January 2011	Map 10. Disparity levels between Metropolises and the surrounding region, 1995-2004
Synthesis Report	51	January 2012	Map 11. Transport policy options and their implications for emissions, 2005
Synthesis Report	57	January 2013	Map 12. Discontinuities of GDP per capita, 2008
Synthesis Report	61	January 2014	Map 13. Typology of the demographic status, 2005
Synthesis Report	64	January 2015	Map 14. Migration flows, 2006-2007
Synthesis Report	66	January 2016	Map 15. Impact of migration on population in 2050
Synthesis Report	69	January 2017	Map 16. Proportion of employment in industries with high energy purchases, 2005
Synthesis Report	71	January 2018	Map 17. Access to urban nodes - Case Study on areas with geographical challenges

ESPON Report	Page number	Date	Title of the figure
Synthesis Report	21	January 2019	Map 2. Unemployment in Europe, March 2010
Synthesis Report	75	January 2020	Map 18. Structural types of rural areas, 2006
Synthesis Report	79	January 2021	Map 19. Change in labour force 2005-2050
Synthesis Report	80	January 2022	Map 20. Change in Working Age Population, 2000-2007
Synthesis Report	84	January 2023	Map 21. Ecological footprint, 2006
Synthesis Report	85	January 2024	Map 22. Human Development Index, 2007
Synthesis Report	91	January 2025	Map 23. Climate change in Europe, 1961-2100
Synthesis Report	94	January 2026	Workers commuting to another NUTS 2 region, 2005
Synthesis Report	97	January 2027	Map 25. Solar Energy Output
Synthesis Report	99	January 2028	Map 26. Wind Power Potential, 2005
Synthesis Report	23 & 24	January 2029	Map 3. Typologies of countries' profiles for trade exports, 1967-2006
Synthesis Report	27	January 2030	Map 4. Networks of multinational firms by Metropolitan Area, 1986-2006
Synthesis Report	28	January 2031	Map 5. Balance of internal and external subsidiaries by Functional Urban Area, 1986-2006
Synthesis Report	32	January 2032	Map 6. World City Network, 2008
Synthesis Report	35	January 2033	Map 7. Centrality within NBIC networks, 1986-2006
Synthesis Report	39	January 2034	Map 9. GDP per capita versus potential multimodal accessibility, 2006
TERCO	12	July 2012	Map 1: Intensity of twinning cities co-operation at NUTS2 level b) Twinning city agreements per 100,000 population
TERCO	13	July 2012	Map 3: Twinning cities with non-ESPON space
TERCO	15	July 2012	Map 5: INTERREG C III and IV partners
TERCO	16	July 2012	Map 8: Number of partners in INTERREG IVB
TERCO	21	July 2012	Map 11 Territorial co-operation in different types of regions
TERCO	34	July 2012	Map 13: Areas that could potentially be extended to two INTERREG B programmes
Territorial Observation No. 1	14	November 2008	Map 7. Baseline scenario: Demographic perspectives. Median age (years)

TASK 2 : 'BEST PRACTICE' IN CARTOGRAPHY OUTSIDE THE ESPON PROGRAMME

Review of existing external guidance documents and standards for "best practice" in cartography and graphic communication. The service provider is asked to review the existing "best practice" in cartography and graphic communication outside the ESPON programme, in particular cartography used in a policy context, focusing on mapping at European level. In fulfilling this task, it is requested that the service provider should analyse, benchmark and draw inspiration from interesting cartographic production also from outside Europe, in a search for innovative approaches that might contribute to a modernised ESPON Cartographic Language.
The review should offer a set of recommendations for cartographic elements to consider in a modernised ESPON Cartographic Language.

- *What documentation is produced in the cartographic field ?*
- *How are maps introduced in reports/books ?*
- *Are the maps produced for spatial planning effective and aesthetic ?*
- *What cartographic rules are applied within these documents ?*

1. Presentation of the Non-ESPON corpus

A corpus of maps developed outside the ESPON programme has been formed. This corpus is needed for the analysis of cartographic practices in the representation of themes concerning spatial and territorial development. It is distinct from the corpus developed in Task 1. Indeed, it is not a "finalised" or exhaustive corpus. The maps selected were not developed within any particular programme or institution, but reflect an exploration of productions intended for publication (paper, or website in pdf format), i.e. without any interactive or dynamic dimension.

Thus the assigned objective of this corpus, which will be referred to as the Non-ESPON corpus, is rather different. The aim is to analyse and understand in what form cartographers, researchers, decision-makers and other players, mainly across Europe, have published graphic representations on the theme of territorial development. The selected documents should enable "good" (or bad) practice in mapping European spatial planning to be highlighted. Thus several issues will be explored in this corpus: can any general trends or modes of representation be observed? Are the cartographic practices the same as those implemented in ESPON during its second period (2007-2013)? What can be learnt from these practices in order to improve ESPON cartographic production as a whole?

Several qualitative criteria enabled definition of the composition of this corpus:
- the subject matter – spatial planning and territorial development, economic, demographic and social analyses, scenarios, thematic atlases

- comparability with the ESPON task 1 corpus - the maps selected are essentially derived from reports or studies described as "applied research" or "targeted research", in the same manner as priorities 1 and 2 in ESPON projects, within the 2007-2013 period.
- the institutions – consideration is given to the widest possible range of bodies producing maps on spatial planning and territorial development, including European organisations and also national and world organisation.
- scale – preferably analyses of phenomena on European scale (European productions) and national scale (search for specific national productions covering the European territory and also the country in question)
- modes of representation – classic cartographic production, but also detection of original productions, whether in the cartographic design (spatial cover, nature and processing of data, grid, layout, presence of other graphic elements etc.), in the semiological options, or in the general structuring of discourse (text-image ratio, use of titles to convey message etc.).

The first phase in the construction of this corpus, on the basis of the above criteria, consisted in selecting a range of graphic documents from different European institutions that produce reports (with or without an infographics department). 167 different documents or reports were consulted. The sources of these documents are as follows:

1/ European Institutions

- European Parliament
- DG REGIO (Directorate General for Regional and Urban Policy)
- DG AGRI (Directorate General for Agriculture and Rural Development),
- DG MOVE (Directorate General for Mobility and Transport)
- JRC (Joint Research Center – European Commission)
- CEMAT (Council of Europe Conference of Ministers Responsible for Spatial/Regional Planning)
- EEA (European Environment Agency)
- IES (Institute for Environment and Sustainability)
- OCDE (The Organization for Economic Co-operation and Development)
- EuroStat (European Statistics)
- FOE (Friends of the earth Europe)
- VASAB (Vision and strategies around the Baltic Sea)
- PartiSEApate (Multilevel Governance in maritime spatial planning throughout the Baltic Sea

2/ National Institutions

- National Statistical Office of different countries (Poland, France, Germany, Switzerland, Romania, United Kingdom, Ireland, Denmark, Sweden)
- National Research Centre or National Institutes on spatial planning and territorial development :
    - EPRC (European Policies Research Centre- Strathclyde University, Glasgow), UK

  - FIRB (The Federal Institute for Research on Building, Urban Affairs and Spatial Development), Germany
  - IRPUD (Institute of Spatial Planning, Technische Universität Dortmund), Germany;
  - Spatial planning Directorate, Republic of Slovenia
  - OSE (Observatorio de la Sostenibilidad en España), Spain
  - Mcrit (Polytechnical University of Catalonia), Spain
  - NEW-ENO (University of the West of England, Bristol), UK
  - IIASA (International Institute for Applied System Analysis, Laxenburg), Austria
  - GAWc (Globalization and World Cities Research Network-Loughborough University), UK
  - EUROREG (Centre for European Regional and Local Studies, Warsaw University), Poland
  - NORDREGIO (Nordic Centre for Spatial Development), Sweden

- National Spatial Planning Institutes and Urban Agencies
  - DATAR (Délégation interministérielle à l'Aménagement du Territoire et à l'Attractivité Régionale), France
  - BRSR (Bundeinstitut fü Bau-Stadt-und Raumforschung, Bonn), Germany
  - BBR (Building Regional Planning Federal Office), Germany
  - IAU (Institut d'Aménagement et d'Urbanisme, Ile-de-France), France
  - ARE (Office fédéral du développement territorial), Switzerland
  - IPI (Irish Planning Institute), Ireland
  - MRDPA (Ministry of Regional Development and Public Administration), Romania
  - RPB (The Netherlands Institute for Spatial Research), Netherlands

- European National Presidencies
  - German Presidency
  - French presidency
  - Hungarian Presidency

- Other Institutes or media
  - Baltic Development Forum (European Investment Bank & Nordic Investment Bank)
  - French web portal about Europe (http://www.touteleurope.eu)
  - IDDRI (Institut du Développement durable et des Relations Internationales), France
  - CERI (Centre for International Studies and research, IEP Paris) France
  - Overview of Spatial Policy (England, Denmark, Germany, Italy and Spain)

3/ World Institutions

A few reports from world institutions are also part of the corpus, to serve as possible references for more original graphic representations. We hypothesised that world-level production, on account of the existence of numerous worldwide databases, could exhibit greater diversity.

- UN (United Nations)
- WHO (World Health Organization)
- GHO (Global Health Observatory)
- WWF (World Wild Fund for Nature)
- UNPD (United Nations Development Programme)
- UNEP (United Nations Environment Programme)

A first corpus was developed. It comprises 208 documents that include at least one map. A first phase of observation of these maps led us to a second stage of selection of a set of 92 maps. This second selection avoids redundancies, maps produced according to the same graphic procedures, or appearing to have little interest in relation to the spatial planning theme of the present work.

An analysis of cartographic practices in the areas of design and implementation was then performed. It was based on precise qualitative criteria covering the various cartographic characteristics observed in the ESPON 2013 map corpus. This enables a comparison of the two corpuses so as to pinpoint the main trends in cartographic design and production in Europe, in particular in the field of territorial development.

2. Cartographic Practices in the Non-ESPON corpus

Generally speaking, this corpus exhibits a clear trend towards fairly classic forms of cartography, although there is greater diversity. Colours and graphic forms used vary, as do geographical cover and scales implemented. Around 48% of the corpus selected uses simple zonal and choropleth cartography. The indicators represented are not very complex either, and generally a single indicator is chosen rather than a superimposition of data. Nevertheless there is a clear trend among national institutions to offer more original cartographic productions. Indeed at national scale, there seems to be greater attention to innovation in the graphic message. At European level it is as if the numerous partners hinder any consensus around original productions. We will see that these maps are not always the most effective, and/or that they are conceptual abstractions rather than cartographic representations. However, this is the present focus: creation requires freedom in choices of representation.

Several specific points need to be explored concerning the analysis of the 92 documents in this corpus. The general guideline for this analysis is the objective of highlighting what can appear as good practice in cartographic design, aspects that appear different from those of the ESPON programme, and the conclusions to be drawn. We therefore consider elements relating to the components of the base map (map projection, generalisation, extent, spatial cover), map layout (legend, additional areas, explanatory text, insets, locator maps, visual arrangement, and of course the graphic translation of the information, that is to say appropriate use of graphic semiology (aspects relating to the data and its representation by way of visual variables). Finally there are a few general remarks on the impact of the production setting on the diversity of the maps produced.

2.1 Geographic Framework and « base map »

Map projection

The Earth, which in mathematical terms is ellipsoid, is a three-dimensional object. Converting this 3D surface into a flat surface is an exercise that is analogous to flattening the peel of an orange on a flat surface. This generates alterations and distortions. Thus choices need to be made to favour either a preservation of angles and distances (conformal projections) or the preservation of surface areas (equal-area or equivalent projections). The corpus observed in the ESPON 2013 programme shows that the choice of projection is that of the azimuthal projection, which consists in projecting the coordinates of the ellipsoid on a tangential plane centred on the space under study. This projection, which preserves surface areas, is a good choice for thematic maps, because it enables the relationships between surface areas of different countries on the map and their actual surface areas to be preserved. It enables the inclusion of geographical information that is proportional to the size of the country (for instance, Africa will indeed be represented as 14 to 15 times larger than Greenland). This projection has become the norm for representation of the European and pan-European space. The Non-ESPON corpus likewise shows a large majority of maps of Europe that use this projection.

There are however exceptions. Indeed, the projection chosen can be used not merely as a simple base for a thematic map. It can also be deliberately chosen to back up the message of the map, to present a particular geographical viewpoint. This produces more unconventional practices. The information is presented from a new viewpoint (for instance Europe seen from Moscow, Figure 2.1), which is a way of influencing the way the map will be read, or a technique for throwing the viewer off balance.

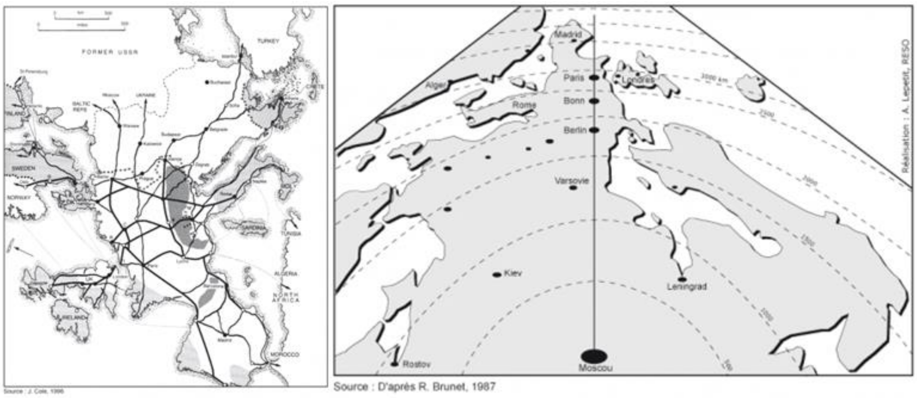


Figure 2.1: Europe, seen from the Ocean (left) & seen from Moscow (right)
Source: (J. Cole 1996) & (Brunet 1987)[11]

[11] http://mapref.org/Annonietal.2003-MapProjectionsforEurope.html

Extent

The projection also has an impact on the geographical cover shown on the map. Indeed, the warping produced by the projection has considerable effect on the edges of the map, and the surface areas represented. The *mapkit* defined for ESPON 2013 allows for only one projection. Thus there is little variation in the extent or cover of the maps. Only two extensions are defined, "wide" and "narrow" (Figure 2.2)

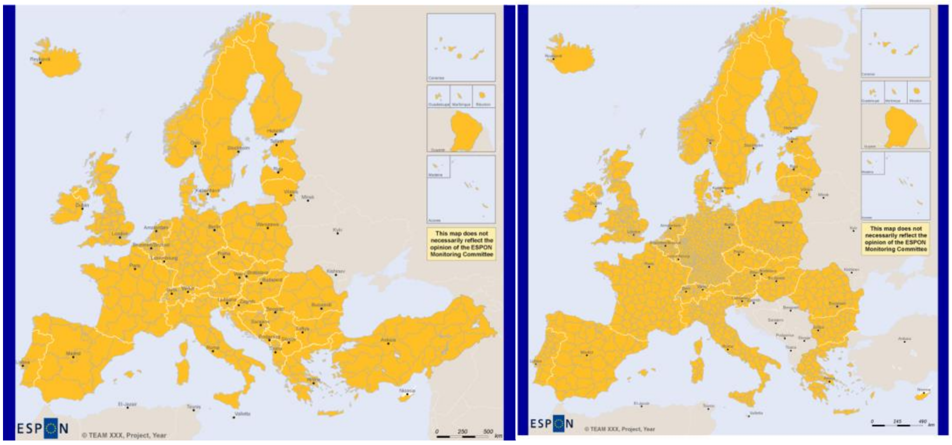


Figure 2.2: Wide and Narrow extensions in ESPON

Yet in cartography the extent should be as coherent as possible with the data represented so that it is the graphic information that dominates. This avoids empty spaces, where non-relevant portions of territory contain no data. Figure 2.3[12] fairly clearly shows the need to suit the geographical cover represented to the information to be conveyed.

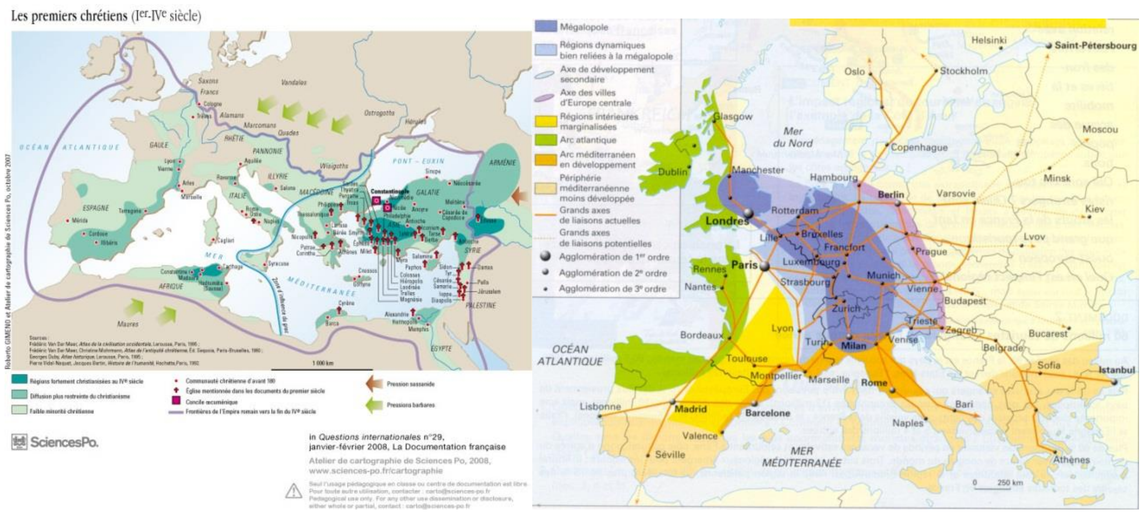


Figure 2.3: Territorial extent and geographical information

[12] http://www.eurogeographics.org/products-and-services/

Generalization

Any cartographic representation involves a compromise between precision and readability (Brunet, 1987, p.51). Thus cartographic generalisation is an operation consisting in simplifying the surface area represented, retaining only the representation of the essential physical or thematic features. Obviously, the decision as to which lines are "useful" in the base map depends on various upstream choices: the purpose of the map, its subject, its scale, and the particular features of the region to be mapped (Beguin, Pumain, 2010, p.20). In physical geography, where relief and the shape of the world are of prime importance for the subject matter, the cartographer will tend to choose a not very generalised base map. Conversely, in human geography, where detailed outlines are often not very relevant, strongly generalised maps will be preferred.

For this reason the Eurographics[13] base map, recommended in the ESPON programme, is not very relevant for representing data on the scale of the European regions. It provides precise information on outlines and boundaries that is not relevant for issues of territorial development. This therefore produces non-useful "noise" that is damaging for the clarity of the map's message. Despite, this, outside ESPON the Eurographics base map is also widely used. This can be seen in maps developed by European institutions as a whole, such as Eurostat, DG REGIO, DG AGRI, EEA or OECD (Figure 2.4). Thus there are marked similarities with ESPON cartography.

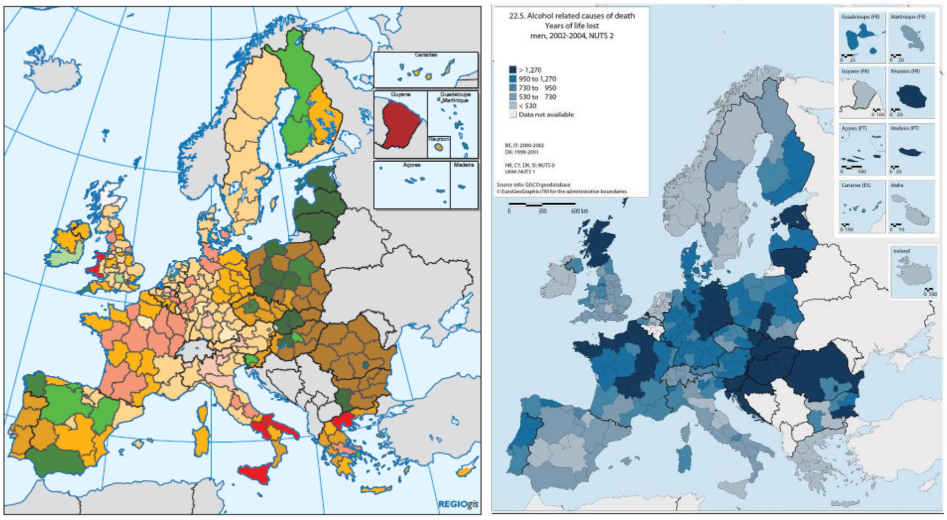


Figure 2.4: Eurogeographics boundaries for Europe
Source: DG-REGIO Regios GIS (left) – Eurostat (right)

There are nevertheless other practices. Certain maps produced within the ESPON programme are improved by removing this "interference". It is the case for instance with an atlas developed by BBR under the German presidency of the European Union. It makes wide use of work produced in ESPON, and has opted for presenting the maps with a more relevant level of generalisation (Figure 2.5).

[13] http://www.eurogeographics.org/products-and-services/

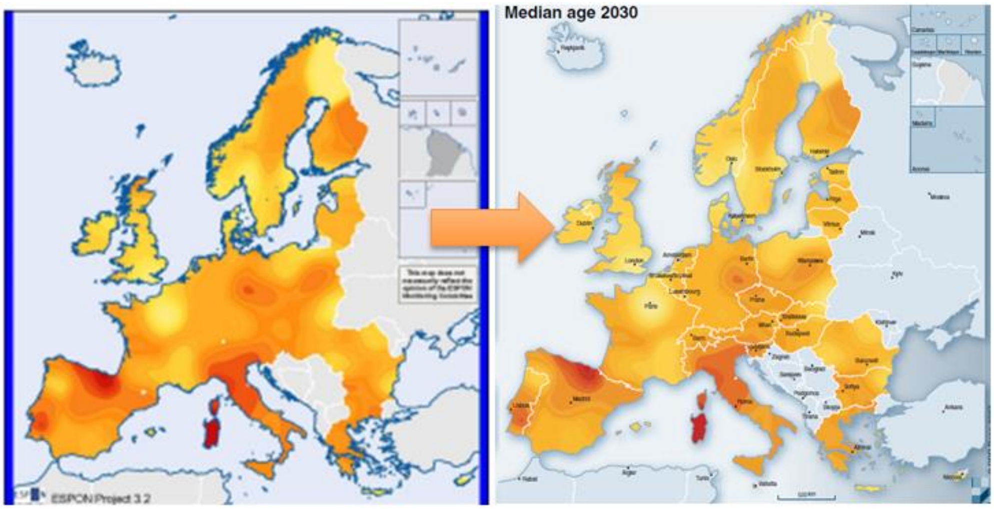


Figure 2.5: Boundary Generalization for Europe ESPON project 3.2 (left) – Maps on European territorial development, BMVBS/BBR, Bonn 2007 (right)

Certain base maps used are specifically dedicated to thematic mapping on the scale of European regions. They are in some instances free-access, as is the case with GREAT[14], a base map under *Creative Commons* licence that uses the same level of generalisation to delineate the European regions from 1980 to the present day. The GREAT base map has been used on many occasions (figure 2.6) in European research projects, whether for the European parliament[15] or in the course of the French presidency of the European Union[16].

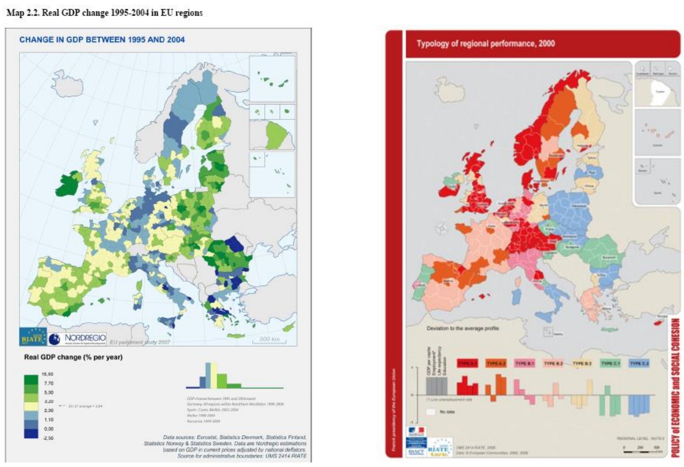


Figure 2.6: GREAT, Generalized base map for Regional European boundaries

It can be added that this base map is also used in ESPON cartographic production, but in the setting of the cartographic analysis undertaken by ESPON HyperAtlas[17] (Figure 2.7).

[14] GREAT (Generalized Representation for European Areas and Territories) Ums Riate
[15] European Parliament, 2007, "Regional Disparities and Cohesion: What strategies for the future".
[16] Datar, *«Mapping territorial cohesion »,* 2008, Informal Meeting of Ministers for Spatial Planning and Territorial Cohesion.
[17] http://www.espon.eu/main/Menu_ToolsandMaps/ESPONHyperAtlas

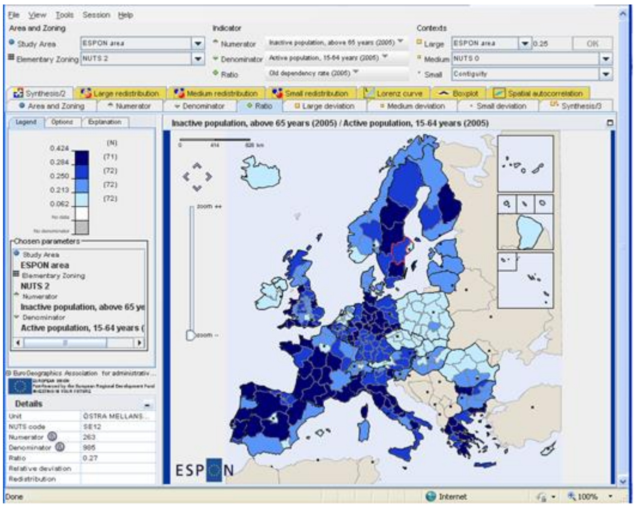


Figure 2.7: ESPON HyperAtlas, 2012

Finally, in certain instances where the cartographic message or the publication context allow, the map loses all or part of the base map. This can be seen in Figure 2.8, developed by DATAR[18], showing the French metropolitan network. The map exhibits a genuine effort to show the information in diagrammatic form, freeing itself from the information provided by the base map. Here the cartographer uses only a few very generalised lines, which are sufficient to localise the phenomenon.

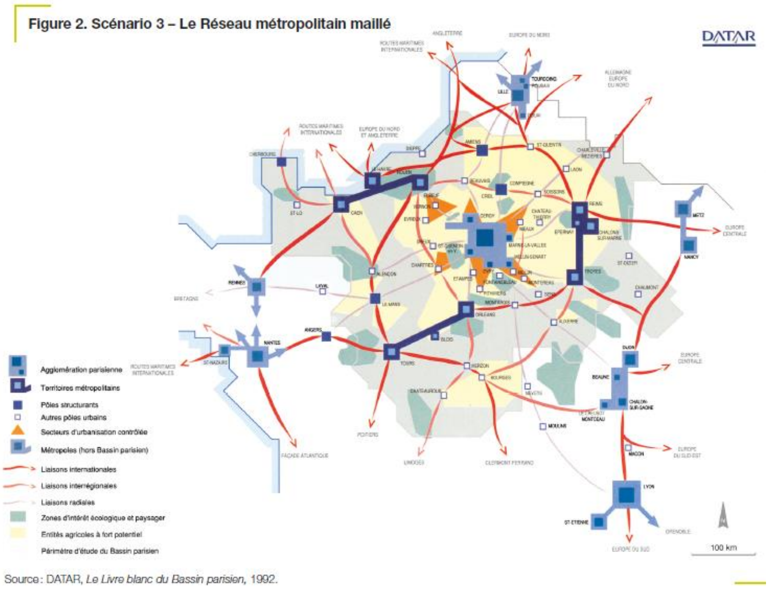


Figure 2.8: The Metropolitan network, DATAR

Taking simplification to the extreme, geometric representations can in some instances actually completely obliterate the base map. This is the case with Dorling's cartogram shown in Figure 2.9. This "map" represents urban populations in 2050. The thematic information is not crowded by any superfluous information. The size of the circles is proportional to the urban populations in each of

[18] http://territoires2040.datar.gouv.fr/spip.php?article42- La DATAR et la prospective, 50 ans d'histoire

the countries in 2050, and the localisation of these circles is based on the centroid of each country, using an algorithm making it possible to avoid super-impositions while at the same time preserving as far as possible the spatial organisation of the territorial units.

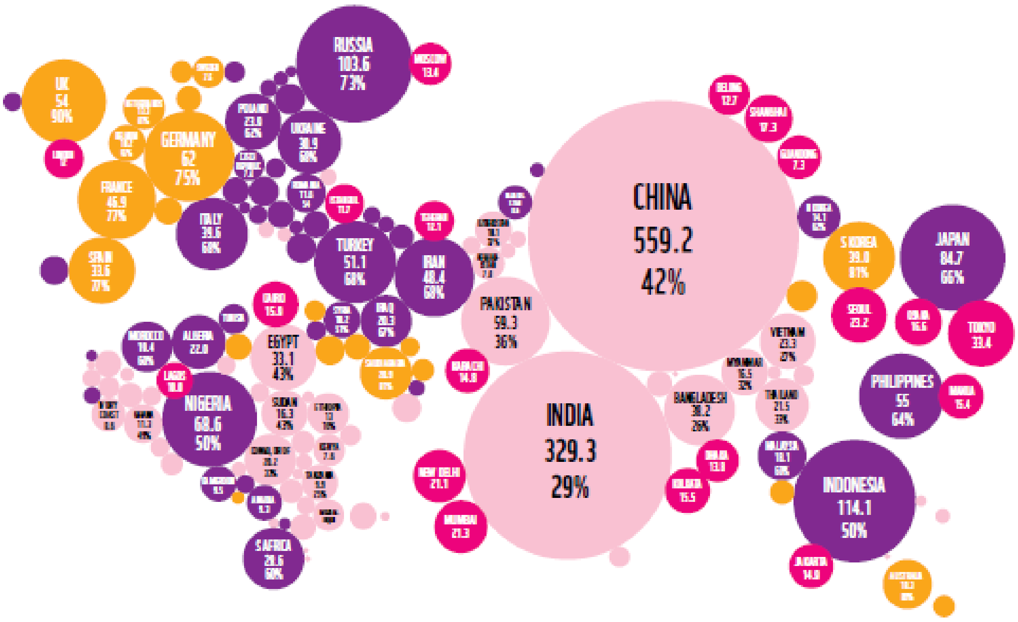


Figure 2.9: Dorling's Cartogram, Urban population in 2050 (UN 2009)

Subdivisions of space

The question of the subdivision of space could appear trivial, since it does not concern representations that are based on administrative subdivisions. Indeed, the subdivision of territory that is represented by the administrative grid is imposed, the data to be represented is collected according to this same grid, and therefore the subdivisions are not open to discussion. However observations and several studies going under the name MAUP[19] clearly show that the subdivisions implemented have a strong impact on the way spatial organisation of a phenomenon is "read", so that they act as genuine spatial filters (Figure 2.10). The size of the territorial units has considerable impact on the reading, all the more so because certain statistical processing steps upstream of the representation are likewise influenced by this parameter. In such cases it is often better to adapt the subdivisions implemented so as to focus on the intended scientific or political message. It is for instance possible, on the same map, to associate NUTS2 and NUTS3. This NUTS2/3 combination then enables homogenisation of the size of the grid, thus markedly improving the visualisation and the comparability of the phenomena, without generating problems in accessing the data.

[19] MAUP (Modifiable Area Unit Problem). Openshaw, S. (1984). The Modifiable Areal Unit Problem. Norwich: Geo Books. ISBN 0-86094-134-5 et ESPON 3.4.3. -MAUP (coord. RIATE, 2006)

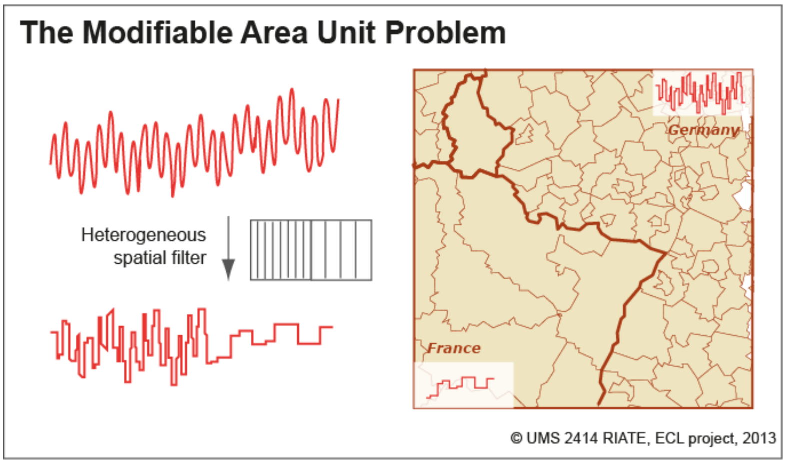


Figure 2.10: The problem of the Modifiable Area Unit

ESPON project 3.4.3 (2006) demonstrates the impact of subdivisions on cartographic representations (figure 2.11). It promotes homogeneous subdivisions so as to produce an image comprising comparable geographical entities. In its conclusion, this report suggested adopting a new NUTS hierarchy for research purposes, emphasising the fact that ESPON is not bound to restrict its cartographic production to the official NUTS2 and NUTS3 subdivisions, which are, among other things, the legal basis for the allocation of structural funds. Even if official delineations can, according to this report, continue to be used in certain instances, the majority of ESPON productions should adopt a revised nomenclature, and a few lines of reflection were proposed.

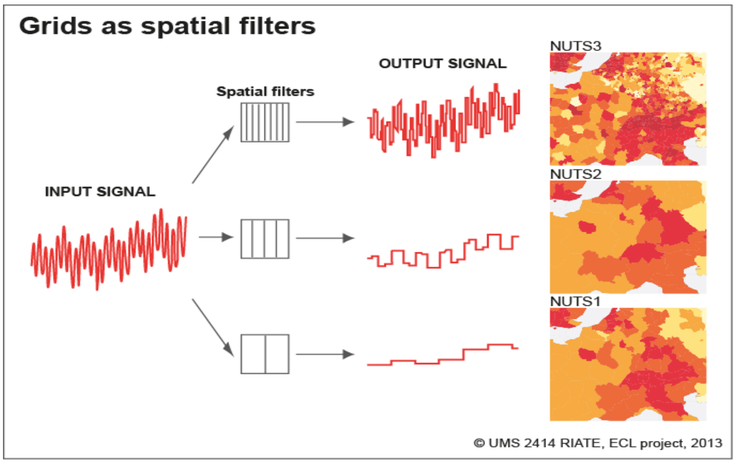


Figure 2.11: NUTS as hierarchical spatial filters

OECD has made this choice. By adopting a combination of NUTS2 and NUTS3 for its regional studies, this organisation has developed an "unofficial" classification of the regions in member states according to different territorial levels (TL) (Figure 2.12). The higher level (TL2) is made up of 362 macro-regions. The lower level (TL3) comprises 1794 micro-regions. Although this classification does roughly correspond to the NUTS nomenclature, alterations have been made. The differences concern Belgium, Greece and the Netherlands where the NUTS2 level corresponds to TL3. In Germany, NUTS1 level corresponds to OECD TL2, while TL3 is obtained by aggregation of the "*Kreise*" to form "spatial planning regions". Finally, for the UK, OECD level TL2 corresponds to NUTS1.

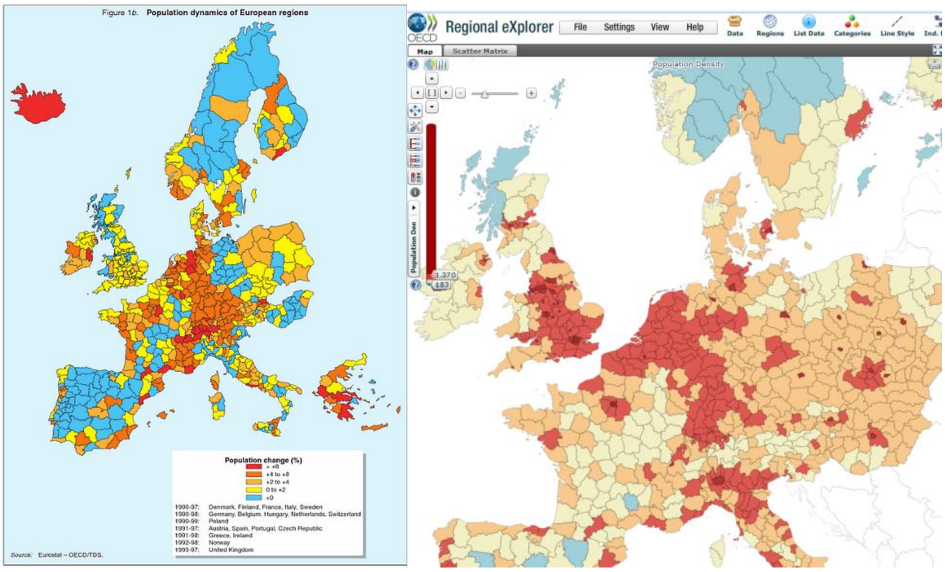


Figure 2.12: OECD, non-official Regions (TL3)
Source: OECD Territorial Outlook 2001(left) and OECD Regional eXplorer (right)

In ESPON Programme cartographic production 80% of the maps are derived from NUTS subdivisions. Among these maps only 4.5% are based on a mixed subdivision composed of NUTS2 and NUTS3 (or more rarely NUTS1 and NUTS2). This is the case for instance for the maps developed for Territorial Observation 1[20] (2008), where NUTS 2 is used for 9 countries (AT, BE, CH, CY, DE, IS, MT, NL, PL) and NUTS 3 for the others, but this is merely for reasons of availability of data, rather than for scientific reasons.

2.2 Layout and style

Legend

Ninety-seven per cent of the maps in the ESPON 2013 programme locate the legend beneath the cartographic image, which tends to disconnect these two elements, despite the fact that by their very nature they are closely linked. As seen in the preceding chapter, this generates empty space on the page. This manner of positioning the legend is probably linked to the provisions included in the *Mapkit*. The analysis of the Non-ESPON corpus, on the other hand, shows that the legend is frequently integrated into the map, close to the image. The map/legend relationship is then better managed, more readable, and the message is quicker to understand. It also enables space to be

[20]http://www.espon.eu/export/sites/default/Documents/Publications/TerritorialObservations/TrendsInPopulationDevelopment/to-no1.pdf

saved, and a better articulation between text and image. An example of this integration of the legend is given in Figure 2.13[21].The reading of the value of the circles is immediate, as is that of the meaning of the colours and arrows.

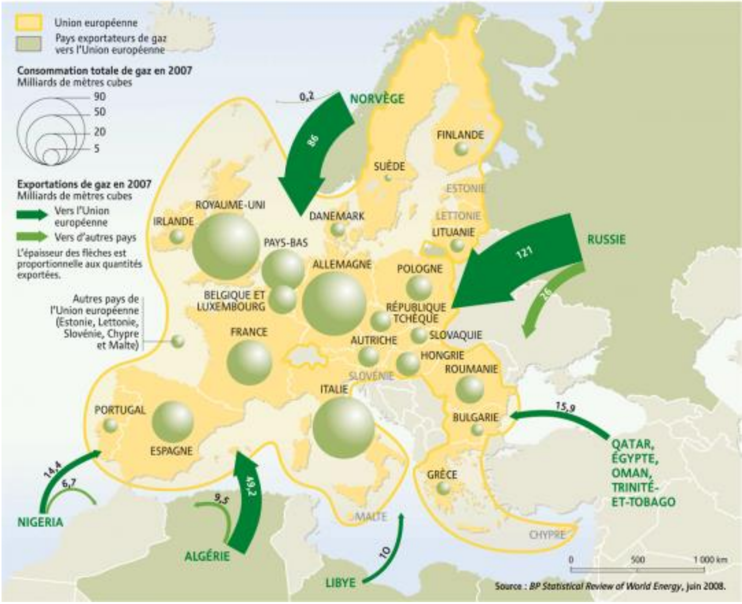


Figure 2.13: Legend and cartographical image, a better link
Source: Philippe Rekacewicz, Le Monde diplomatique, 2007

Toponyms and visual indicators

Cartographic production also requires the right balance between the representation of the subject matter and the actual indicators enabling places or data to be located. These elements can be place names, or representations of territories belonging to the places represented from an administrative point of view but located outside the base map chosen. The semiological rule is to make these signs as unobtrusive as possible so as to avoid hampering the perception of the message, but also to use them to foster understanding or improve the aesthetics of the map. In cartography, these elements need above all to be linked to the theme of the map.

In ESPON the only visual sign imposed by *Mapkit* is the representation of the capital cities. These may be relevant for the theme of the map, and thus contribute to the understanding of the message. However they are often not useful, and may even go against the message intended.

There is also the problem of the representation of territorial units that are considered important, but that are too small to accommodate readable information on the map. This occurs for instance with small European territories such as Malta or Lichtenstein. They are generally presented in insets, as are remote areas, increasing their size so as to make them easier to view. Numerous organisations adopt this strategy. The Eurostat map in Figure 2.14 is a good example.

[21] http://www.monde-diplomatique.fr/cartes/europeenergetique

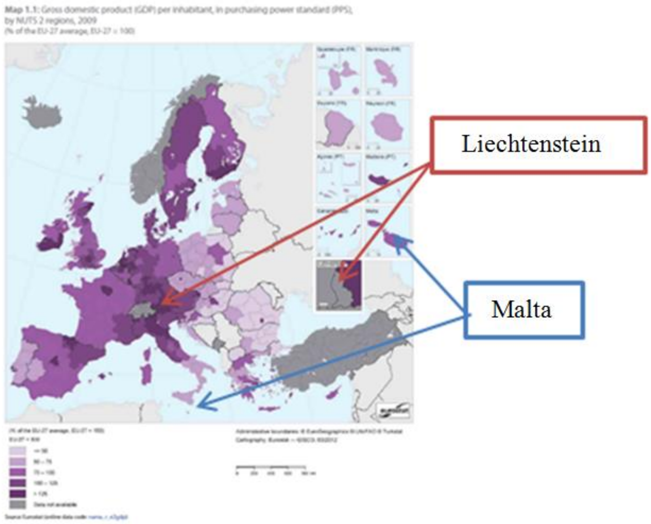


Figure 2.14: Remote areas and smaller countries
Source: Eurostat Regional Yearbook 2012, p. 20

2.3 Data and graphic semiology

Data

The nature of the data has a direct impact on the way a map is designed. This is particularly true for the representation of environmental data, which generates maps that are very different from maps on socio-economic themes. Indeed, environmental data often involves different geographical objects (triangulation points, grids, river basins etc.) so that the maps are *ipso facto* more original, in particular compared to ESPON cartographic production. One of the elements exhibiting these differences is the projection chosen. In the case of environmental maps, the projection will not relate to a cartographic choice so much as to the actual data. When the data is available in the form of a regular square grid, as is the case with Corine Land Cover data, or when it is available for latitude and longitude (climatic data) the cartographic representation will comply with the nature of the data by using a regular grid, even if the general appearance of the territory represented is not ideal (Figure 2.15).

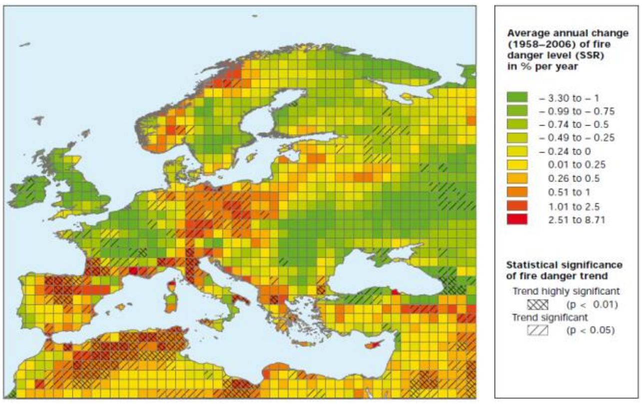


Figure 2.15: Data and Grid, original solution for a specific theme
Source: JRC Reference Report 2008-2009 on Climatic Change p.147

World organisations, which provide data for long time spans, produce cartographic representations that are often articulated with other graphic elements. Since temporal data may lend itself more to diagrammatic representations than to maps, it can generate layouts that show both a given state (map) and an evolution (graphic diagram). Examples are shown in Figure 2.16.

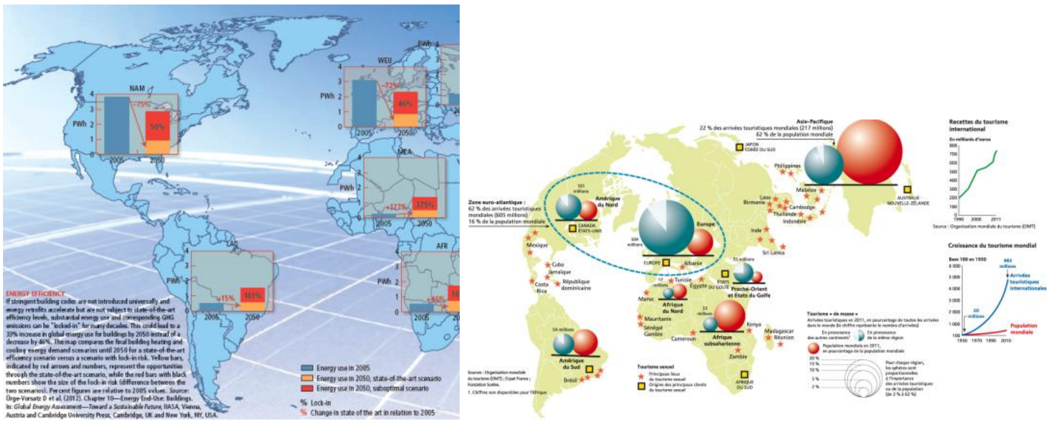


Figure 2.16: Map and Graphic
Sources: IASA, Options Summer 2012 Rio+20 p. 18 (left) Le monde diplomatique June 2012 (right)

Finally, spatial interaction data often generate original maps comprising lines and arrows. This type of data (relating to links and flows) is not well represented in ESPON, because little data is available. Conversely, at world or national level these maps are fairly common and they are generally fairly elaborate maps (Figure 2.17). There is hardly any no software available enabling the optimal positioning of arrows on a map, which makes them difficult to design.

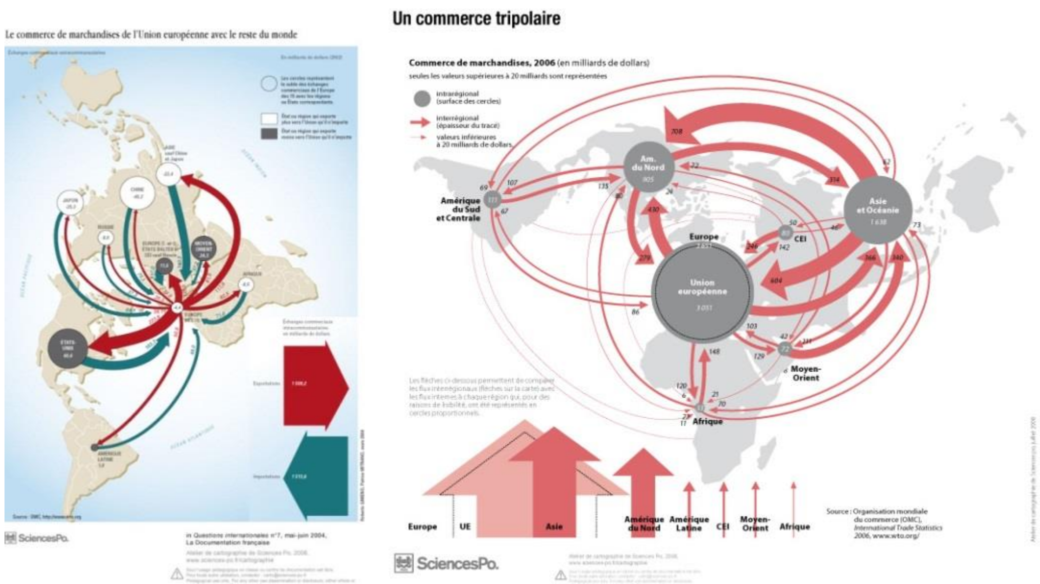


Figure 2.17: 2 examples of flows maps at world level
Sources: Atelier de cartographie de SciencesPo 2004 (left) 2006 (right)

Graduated Symbol or Choropleth maps

When analysing the maps produced in ESPON 2013 we noted a marked predominance of maps using coloured areas rather than graduated or proportional symbolisations. ESPON cartographic production is characterised by a preponderance of intensity variables and relatively little use of stock (raw) variables. Maps presenting intensity variables show relationships and ordered information that does not take account of the size of the spatial units involved, nor of any link with the general scale of the phenomenon. In a political perspective, it could be said that these are maps aiming to work on a consensus. Conversely the maps involving stock variables (Figure 2.18) show absolute weights. These maps relate more clearly to the notions of power and hierarchy. The representation of masses generates a power relationship between territories.

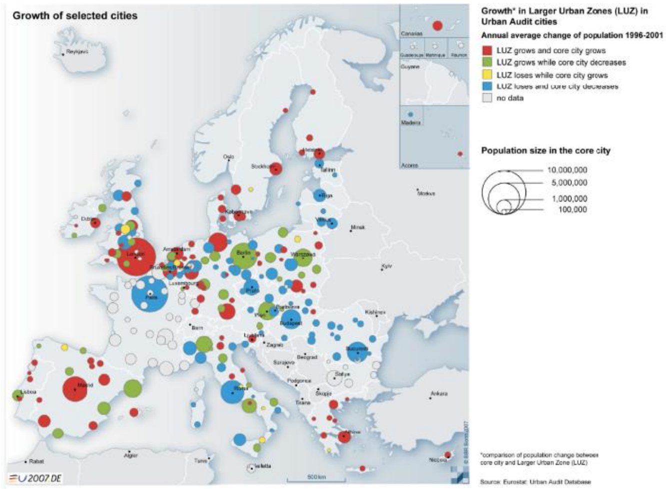


Figure 2.18: A Graduated Symbol maps, territorial power
Source: Maps on European territorial development, 2007, BBR

The explanation for this predominance of the use of intensity variables could be technical, since map developers tend to be computer scientists or computer-oriented, and they often use a software environment derived from GIS, where there are standard functions proposing representations using layers of coloured polygons. The representation of graduated symbols is more complex. A second reason is no doubt psycho-sociological, and arises from habit and inertia, leading to rather commonplace views of the world and an avoidance of the more polemic representations.

Territorial or Conceptual Maps

The overall Non-ESPON cartographic corpus exhibits greater diversity in the styles of cartographic representation. Numerous maps are nevertheless classic, with the title at the top left, the legend below, using classic semiology of coloured areas representing indexes, typologies or ratios. There are recent maps with a rather out-dated style, such as that shown in Figure 2.19 which seeks to provide information on the construction of the European Union. The information needs to be read, rather than being perceived visually.

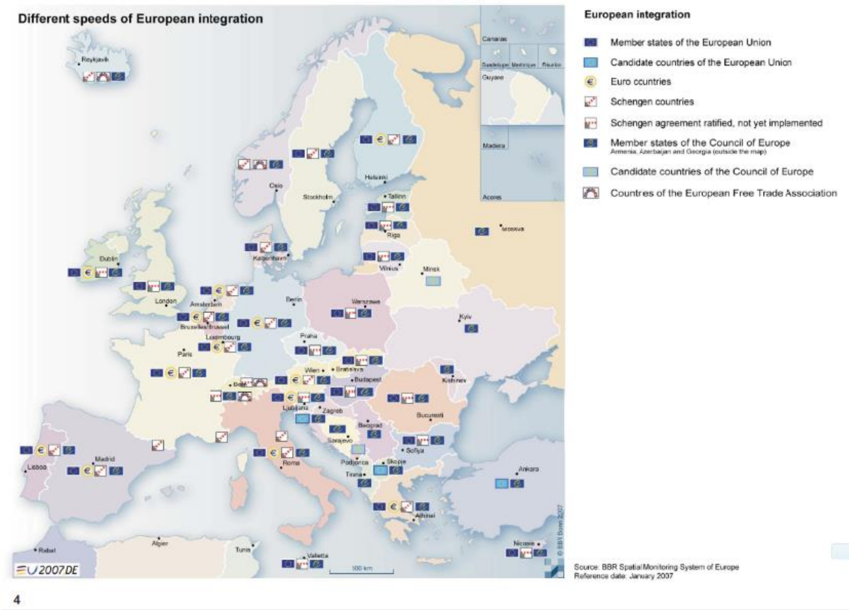


Figure 2.19: A not very effective map designed to be read
Source: BMVB, Germany, 2007

However there is a more noticeable trend. There is an original form of production among national map-producing bodies, or bodies specialised in territorial development. Here can be seen attempts to reconcile the concepts to be conveyed and their representation, where the classic map gives way to a purely conceptual representation. The maps presented in Figure 2.20 illustrate this diversity, which appears to be a French and German speciality.

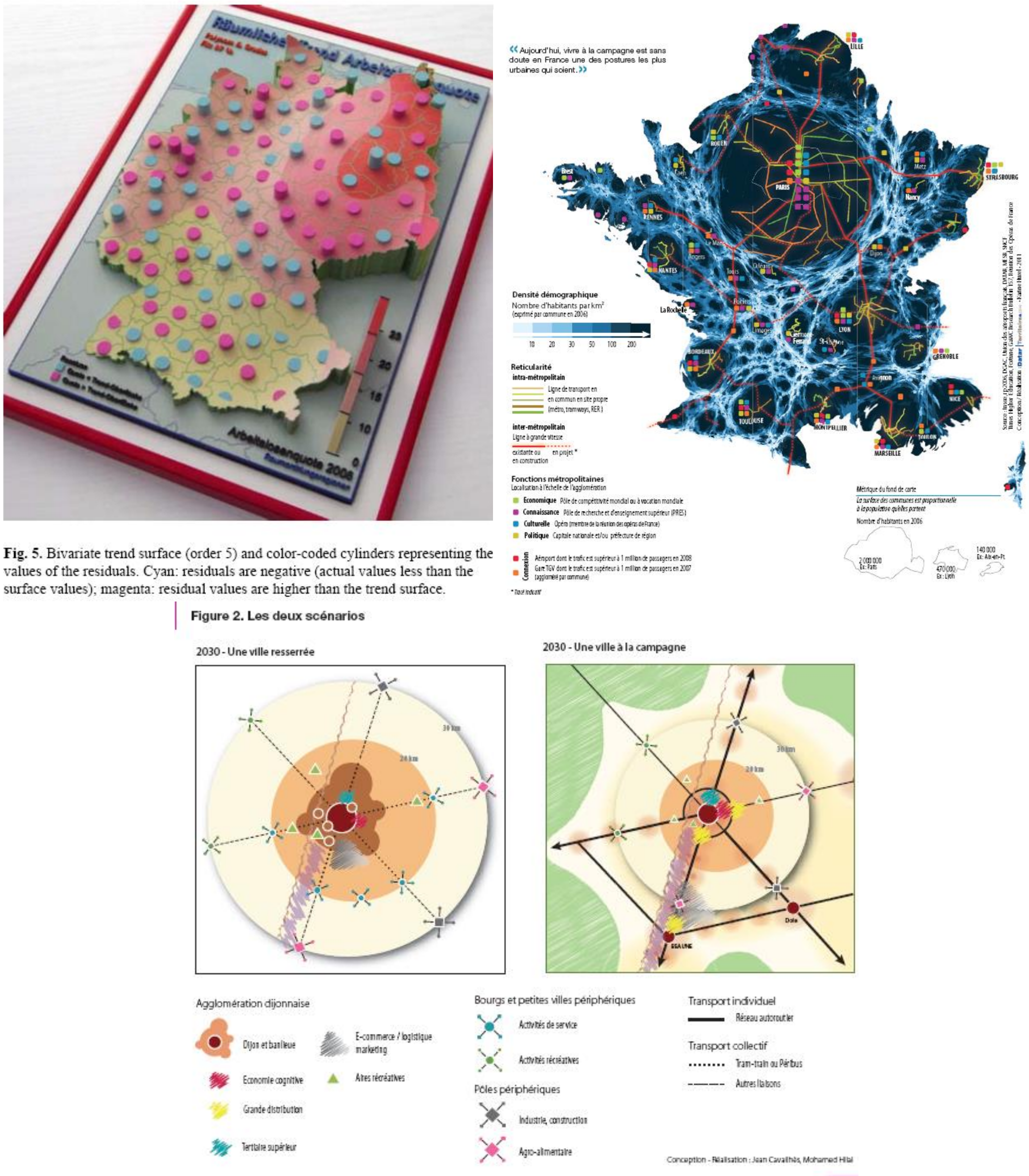


Figure 2.20: Maps and geographical concepts
Source : W.D. Rase [22] (left), Datar Territoire 2040 n°3 p.17 (middle) Datar Territoire 2040 n°2 p.107 (right)

2.4 Production context

Besides the characteristics of the cartographic production *stricto sensu*, the setting in which the map is produced plays some part. The types of institution producing the map, their decision-making processes, or their links with scientific networks clearly affect the variety and the characteristics of their maps. Several trends can be seen.

[22] W.D Rase, 2012, Creating Physical 3D Maps Using Rapid Prototyping Techniques in True 3D in Cartography, p. 119-134

Impact of the institution

The most original maps are those that do not use the standard study scale implemented by the organisation. For instance, the maps produced by Eurostat, where the scale of study is Europe, are very homogeneous for the representation of the European space, almost identical to those in ESPON 2013. The production of these maps is highly standardised, and the colours and graphic styles are precisely defined. In contrast, the cartographic originalities in ESPON most often involve representations of the pan-European or world space, although this type of work tends to be marginal. This also seems to apply to other institutions. Indeed, the original representations of Europe originate from national or world bodies that have not established strict rules, and that have few set habits in the mapping of Europe. Thus innovation is found more frequently on pioneer fronts and in the periphery.

Impact of the decision-making process

A second trend can be noted. This concerns decision-making and map design. Indeed, when the process of validating a map is linked to collective decisions involving a consensus, there is a trade-off among the different cartographic options on the table. This trade-off to the smallest common denominator does not favour risk-taking and iconoclastic representations, since by definition they do not obtain a consensus. Conversely, decisions reached by a single player are easier, and enable development of atypical productions. In ESPON, where the decision-making procedures involve representatives from all 31 countries concerned in the programme, it is thus specified that each country should be represented on the map, even if there is no corresponding data to show, or even if the values are too small to be seen on the map.

Impact of the production process

The maps also depend very much on the cartographic culture of the organisation producing them. Roughly speaking, cultures can be more computer-oriented, or more cartography-oriented, rarely both at once. Maps developed by computer specialists are generally constructed using state-of-the-art tools and technologies which enable series of maps to be produced, in a form of chain production. The maps produced in this manner remain very homogeneous, but their cartographic "power" is fairly small. All the maps are developed in the same manner, whatever their themes or the phenomena represented.

In contrast, maps designed by cartographers appear more "rough and ready" (Figure 2.21). Technical tools can be set aside in favour of more creative cartography, since each map is constructed individually to deliver a targeted message. These are therefore "one-shot" maps serving to demonstrate something, and they are consequently all very different and by definition very original.

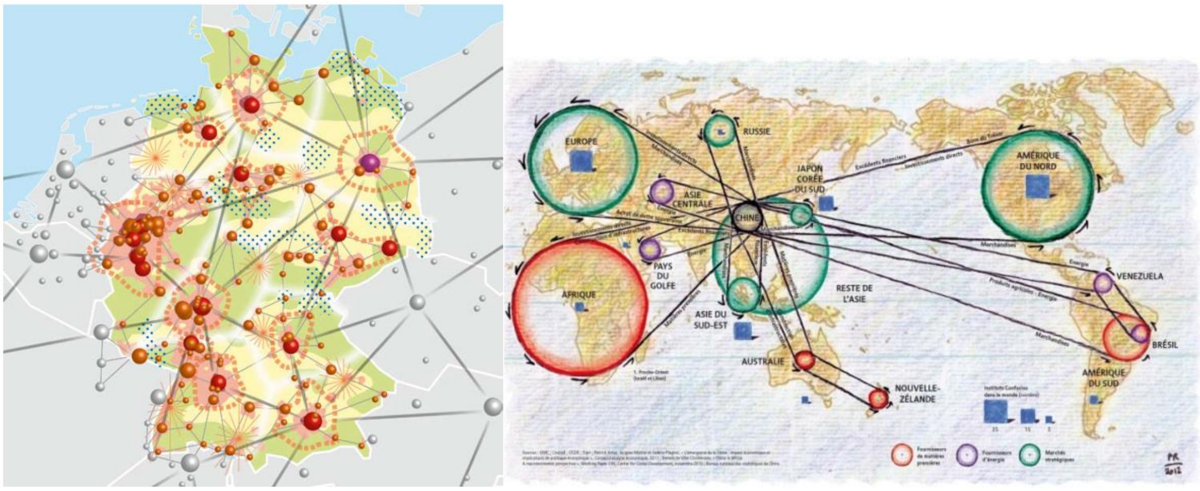


Figure 2.21: Cartographic creativity
Source: BBR2006[23] (left), Ph. Rekacewicz 2012

23 Concepts and Strategies for Spatial Development in Germany. Adopted by the Standing Conference of Ministers responsible for Spatial Planning on 30 June 2006

CONCLUSION Task 2: Diversity more widespread within non ESPON corpus

Non-ESPON cartographic production has less marked characteristics than the production explored in the ESPON corpus. Representations are clearly less homogeneous, and diversity is more widespread.

• There is considerable similarity between ESPON cartographic production and that of other European organisations;

• There are few cartographic errors (graphic semiology fairly well applied);

• Cartographic originality is observed when institutions are not weighed down by excessive standardisation, which seems to be damaging for creativity and innovation. Innovation also occurs when the maps are designed for territories that do not involve the usual spaces represented, for instance when a given state produces a map of Europe;

• Innovation also appears to be favoured by the closeness of links between the institution producing the map and scientific, Geomatic or Geovisualization research;

• The geomatic culture of the organisation has considerable impact on its cartographic production.

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Report Name	Page number	Date	Title of the figure
AEE_Observed_Climate_Change_Impacts_2008	139	2008	Modelled change of flowering date for winter wheat 1975–2007
AEE_Observed_Climate_Change_Impacts_2008	143	2008	Rate of change of the meteorological water balance 1975–2007
AEE_Observed_Climate_Change_Impacts_2008	147	2008	Average annual changes in fire danger level 1958–2006
agences_urbanisme_France	4	2012	Le choix d'un large schéma de cohérence territoriale pour le sud de la Meurthe-et-Moselle
agences_urbanisme_France	15	2012	Intégrer urbanisme et transport : un contrat d'axe pour la ligne Nîmes-Alès
agences_urbanisme_France	22-23	2012	Les projets de poles metropolitains
agences_urbanisme_France	22-23	2012	Les agences de l'espac e Paris-Seine-Normandie en réseau pour l'axe Seine
agences_urbanisme_France	22-23	2012	Le Sillon lorrain : un réseau d'agences pour le pôle métropolitain
Atlas mortality_Eurostat	180	2009	Alcohol related causes of death Years of life lost men, 2002-2004, NUTS 2
BBSR_Fachkraftemangel_2012	35	2012	Die Stadt-Land-Regionen
BBSR_Fachkraftemangel_2012	36	2012	Bevölkerungs- und Beschäftigtenentwicklung in den Stadt-Land-Regionen 2000 bis 2009
BBSR_Fachkraftemangel_2012	44	2012	Prognostizierte Bevölkerungsentwicklung in den Bundesländern insgesamt und nach Altersgruppen, 2010 bis 2025
BMVBS_2006	1	2006	Germany
BMVBS_2006	11	2006	Germany in the European area
BMVBS_2006	13	2006	Concept: Growth and innovation
BMVBS_2006	19	2006	Concept: Securing Services of public Interest
BMVBS_2006	23	2006	Concepts: conservation of ressources, Shaping of cultural Landscapes
BMVBS_2007	4	2007	Different speeds of European integration
BMVBS_2007	5	2007	Population development over a longer period
BMVBS_2007	6	2007	Components of population development over a short period
BMVBS_2007	7	2007	Development of the urban population
BMVBS_2007	8	2007	Growth of selected cities
BMVBS_2007	**9**	2007	Regional economix strength and development
BMVBS_2007	15	2007	Inner-city disparities in unemployment in selected cities
BMVBS_2007	17	2007	Spatial structure of Europe
BMVBS_2007	20	2007	Internet Exchange Points and the main european networks
BMVBS_2007	23	2007	Natural hazards
BMVBS_2007	28	2007	Potential paths of economic developement
BMVBS_2007	30	2007	Climate change-development of temperature by the end of the 21st century
BMVBS_2007	31	2007	Climate change - development of precipitation by the end of the 21 st century

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CERI_SciencesPo	web	2006	Un commerce tripolaire
CERI_SciencesPo	web	2010	La zone euro et la croissance en Europe (1990-2007)
CERI_SciencesPo	web	2008	Etats-Unis/Europe: répartition du PIB par Etat
CERI_SciencesPo	web	2010	Coefficient de Gini (2008)
CERI_SciencesPo	web	2007	l'enchevêtrement européen, jancier 2007
CERI_SciencesPo	web	2009	Les camps d'étrangers en Europe et dans les pays voisins, 2007
CERI_SciencesPo	web	2010	Aide au développement de l'Union européenne en 2009
CERI_SciencesPo	web	2010	l'enchevêtrement européen, septembre 2010
CERI_SciencesPo	web	2010	Programmes de coopération transfontalière, 2007-2013
CERI_SciencesPo	web	2010	PIB par habitant dans les regions européennes, 2007
CERI_SciencesPo	web	2010	Infrastructures d'approvisionnement en Gaz de l'UE, 2010
CERI_SciencesPo_enLigne	web	2004	le commerce de marchandises de l'Union européenne avec le reste du monde
CPB Netherlands Bureau for Economic Policy Analysis	132	2010	Main scenario characteristics
CPB Netherlands Bureau for Economic Policy Analysis	163	2010	Four scenarios
DATAR_8cooperations_ 7Metropoles	32	2006	État des lieux des coopérations sur la Rade de Toulon
DATAR_Systemes_urbains_ francais	9	2012	Les trois échelles des liens des systèmes urbains français
DATAR_Typo_Campagne_ n Litto_Montagnes	73	2012	Typologie des espaces ruraux (Segesa 2003)
DG_Agri_Preparing_Change	100	2009	Changes in farm income at regional level in the EU-27 in the 2020 Reference (left figure), Conservative CAP (centre figure) and Liberalisation (right figure) scenarios (percentage difference
DG_Agri_Preparing_Change	143	2009	Observed changes in annual precipitation 1960 to 2006
DGAGRI	24	2010	Result of the clustering exercise
DGAGRI	167	2010	The results of the first clustering exercise at NUTS3 level for which 24 variables were used
DGREGIO_Fifth_Report_2010	6	2010	Russia, India, China and Brazil: Regional GDP per head, 2007
DGREGIO_Fifth_Report_2010	15	2010	Change in regional GDP per head (PPS), 1995–2007
DGREGIO_Fifth_Report_2010	35	2010	Population aged 30–34 with a tertiary education in 2008 and distance to Europe 2020 target
DGREGIO_Fifth_Report_2010	54	2010	Regional innovation potential, 2008
DGREGIO_Fifth_Report_2010	99	2010	Homicide rate, 2005
DGREGIO_Fifth_Report_2010	133	2010	Passenger flights of less than 500 km, 2008
DGREGIO_Fifth_Report_2010	133	2010	Highest speed on railway sections according to timetables, 2010
DGREGIO_Fifth_Report_2010	136	2010	Land cover/land use in selected cities, 2006
DGREGIO_Fifth_Report_2010	255	2010	Real GDP change due to TEN-T investments
DGREGIO_National_ Strategic_2008	11	2008	Cross-border cooperation

Report Name	Page number	Date	Title of the figure
EEA	119	2012	Occurrence of major floods in Europe (1998–2009)
EEA	119	2012	Projected change in river floods with a return period of 100 years
EEA	132	2012	Trends in spring phenology in Europe (1971–2000)
EEA	140	2012	European variations in the temporal trend of bird and butterfly community temperature index
EEA	171	2012	Projected change in water availability for irrigation in the Mediterranean region by 2071–2100
EEA	226	2012	Factors determining vulnerability to heat waves
EEA	228	2012	Pojected climate change
ET2050	web	2005	Vision spatiale de l'Espace atlantique
ET2050	web	2010	Comprehensive, integrated map vision for the baltic sea regions 2010
ET2050	web	2010	Enhancing maritime spatial planning and management
ET2050	web	2010	Improving internal and external accessibility
ET2050	web	2010	Territorial development perspective
ET2050	web	2004	Pentagon et périphérie
ET2050	web	2009	Qué quiere Alemania?
ET2050	30	2000	Une vision pour l'Europe du Nord-Ouest
ET2050	web	2000	Gateway and relay systems
ET2050	web	1992	Western Mediterranean-trend scenario
European commission	5	2011	Tyopology of metro regions
European Parliament	7	2007	Real GDP change 1995-2004 in EU regions
European Parliament	11	2007	Spatial approach: the return of powerful metropolitan areas?
Euroreg	209	2010	The functional metropolitan Stockholm Mâlar region
Euroreg	235	2006	Destination of migration from the metropolitan area
Eurostat regional yearbook	20	2012	Gross domestic product (GDP) per inhabitant, in purchasing power standard (PPS),by NUTS 2 regions, 2009
Eurostat regional yearbook	21	2012	Gross domestic product (GDP) per inhabitant, in purchasing power standard (PPS), by NUTS 3 regions, 2009
Eurostat regional yearbook	165	2012	Total resident population in Urban Audit core cities, 2008
Eurostat regional yearbook	184	2012	Maritime passengers in EU coastal regions, by NUTS 3 regions, 2010
Eurostat regional yearbook	195	2012	Types of clusters
Eurostat regional yearbook	196	2012	Degree of urbanisation for local administrative units level 2
Eurostat regional yearbook	197	2012	Urban–rural typology for NUTS level 3 regions
FOE_Europe	web	2011	EU FUNDS IN CENTRAL AND EASTERN EUROPE ROADMAP TO SUSTAINABILITY OR DEAD-END INVESTMENTS?
GAWc	web	2010	Global cities in harmonious development

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Gloersen	23	2012	Icône associées au polycentrisme dans le schéma de développement de l'espace communautaire
Gloersen	34	2012	La dorsale européenne ou "banane bleue"
Gloersen	34	2012	Le modèle polycentrique ou "grappe de raisins"
Gloersen	50	2012	Le fonctionnement en réseau des activités motrices de l'intégration mondiale exemple des places bourcières
Gloersen	55	2012	Hypothèse volontariste de développement à long terme proposée par la CRPM
Gloersen	56	2012	Délimitation des systèmes urbains actuels et potentiels de l'Europe par la CRPM
Gloersen	56	2012	Vision spatiale pour un meilleur équilibre territorial proposée par METREX
Gloersen	75	2012	Identification spéculative d'identification de "zones géographiques d'intégraion économique d'importance mondiale"
Gloersen	112	2012	Résidus d'une corrélation linéraire entre accessibilité et produit régional brut en Europe
Gloersen	139	2012	Plus haut niveau de subdicision traditionnelle en norvège, Suède, Finlande et au Danemark
IDDRI	25	2013	les douze regions du modèle
IDDRI	27	2013	Décomposition de l'emprise énergétique en énegie grise et énergie directe
IDDRI	28	2013	Comparaison des emprises avec les bilans classiques (AIE)
IIASA_2012	18-19	2012	energy efficiency
Images_Eco_Monde_2013		2012	Les détenteurs de la dette publique des Etats-Unis
IRPUD	web	2000	Wheel Radius Travel Time
LeMondeDiplomatique	web	2011	L'Arctique
LeMondeDiplomatique	web	2000	Vers une nouvelle géopolitique africaine
LeMondeDiplomatique	web	2011	Population sous alimentée
LeMondeDiplomatique	web	2011	Tourisme
LeMondeDiplomatique	web	2012	Machinerie mondiale
LeMondeDiplomatique	web	2012	Le monde arabe
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Living_report_2012	59	2012	Figure 38: The number of people living in cities in each country of the world in 2010, together with the percentage of the population in countries with large urban populations.
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SPESP-Mcrit 1998-1999	web	1999	The Regional Impact of the Channel Tunnel throughout the E.C.
SPESP-Mcrit 1998-2000	web	1999	Europe 2015 by TGV perspective
SPESP-Mcrit 1998-2001	web	1999	Daily accessibility to GDP, without high-level network (top), and by rail in 1996 (bottom)
SPESP-Mcrit 1998-2002	web	1999	The Network/Poly-centric paradigm

Report Name	Page number	Date	Title of the figure
METREX_2009_Conference_planning_sustainable_metropolita	26	2009	Regional system of open spaces
METREX_2009_Conference_planning_sustainable_metropolita	26	2009	General end-uses of the different parts of the territory
METREX_2009_Conference_planning_sustainable_metropolita	25	2009	Purposive mobility of people
METREX_2009_Conference_planning_sustainable_metropolita	25	2009	Reducing territorial, social and environmental inequalities
METREX_2009_Conference_planning_sustainable_metropolita	42	2009	The North Africa Europe solar network in 2050
METREX_2009_Conference_planning_sustainable_metropolita	46	2009	Polycentric regionplan 2030 metropolitan area Rotterdam/The Haghe
METREX_2009_Conference_planning_sustainable_metropolita	63	2009	Potential GDP in Europe within a radius of 100 km, 2005
Nordic_perspectives_ demography	64	2012	Total population change in the European and Arctic regions2000-2010
Nordregio	web	2006	Commuting 2004
Nordregio	web	2006	Evolution of the population working in the tertiary between 1991 and 2006
Nordregio	web	2006	Classification of the regions according to their proportion of employees in the three main sectors in 2006%
Nordregio	web	2012	Projected change in population 2006-2020
Nordregio	web	2010	Trade between the Nordic Countries in 2009
Nordregio	web	2011	Population density LLM and localities >5000 inhabitants
Nordregio	web	2011	A typology of Nordic Local Labour Markets
Nordregio	web	2009	Europe wind power potentials
Nordregio	web	2009	River Basin Districts in the BSR and eutrophication (2009) in the baltic Sea
Nordregio	web	2009	Generation of electricity by source
Nordregio	web	2009	Migration between the Nordic countries in 2009
Nordregio	web	2011	Total Population and change
Nordregio	web	2010	Population density at NUTS3 level in 2010
Nordregio	web	2011	Demographic Vulnerabilities in 2011
Nordregio	web	2013	Structural Funds 2007-2013 Transnational Cooperation Areas
NWEurope	14	2005	Depopulation areas
NWEurope	14	2005	Population concentration
NWEurope	15	2005	Suggested typology of areas
NWEurope	15	2005	The Spatial Vision Diagram 2000
NWEurope	16	2005	The ‘Blue Banana’ compared with areas with a demographic potential of over 1 million inhabitants
NWEurope	51	2005	Examples of transnational corridors with considerable potential for coordinating regional strategies in north-west Europe
Regiony_Polski_2012	47	2012	Regions of Poland

Report Name	Page number	Date	Title of the figure
SOER_EEA	62	2010	Exceedances of critical loads for eutrophication due to the deposition of nutrient nitrogen in 2000
SOER_EEA	65	2010	Proportion of fish stocks within and outside safe biological limits
SOER_EEA	98	2010	Estimated years of life lost (YOLL) in reference year 2005 attributable to long-term PM exposure
SOER_EEA	123	2010	Main drought events in Europe, 2000–2009
SOER_EEA	137	2010	A selection of global drivers of change relevant for the European environment
SOER_EEA	148	2010	Potential climatic tipping elements
SPESP	24	1999	Global, regional and local urban centres in Europe
SPESP	25	1999	Regional types of urban-rural spatial patterns
SPESP	44	1999	Case Studies
SPESP	71	1999	Orthodromic distance to the centre of gravity of population in Europe
SPESP	72	1999	Accessibility by road to population in 1996
SPESP	73	1999	Accessibility by rail to population in 1996
SPESP	74	1999	Accessibility by air to GDP in 1996
SPESP	78	1999	Selected fields for a systematic approach of spatial integration in cross-border regions
SPESP	91	1999	Manual cross table of cause and effect indices
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SPESP	95	1999	Scale and resolution for Spain
SPESP	103	1999	Diversity index of cultural landscape
SPESP	106	1999	Presence of cultural assets
SPESP	120	1999	GDP per inhabitant 1995
Suisse_2012	web	2012	Mettre en place des territoires d'action et renforcer le réseau polycentrique de villes et de communes
Territoires_2030_n4	60	2007	Évolution relative de la pauvreté, indice SCOTDEP 1981-2001
Territoires_2040_n1	22	2010	Les villes millionnaires dans le monde
Territoires_2040_n1	37	2010	Étapes de construction du cartogramme de la population des communes
Territoires_2040_n1	38-39	2010	Cartes iconiques des sept systèmes spatiaux de Territoires 2040
Territoires_2040_n1	46	2010	Les trois leviers d’action
Territoires_2040_n1	48	2010	Un exemple de chorème, extrait du chantier « Pour un mieux-vivre urbain »
Territoires_2040_n1	53	2010	Scénario 3 – Le Réseau métropolitain maillé
Territoires_2040_n1	54	2010	Systèmes urbains et territoires : esquisses à long terme
Territoires_2040_n1	55	2010	Scénario 4 – Le polycentrisme maillé
Territoires_2040_n1	55	2010	Image produite dans le cadre du groupe « Territoires et cyberespace en 2030 »
Territoires_2040_n1	60	2010	Un monde majoritairement urbain
Territoires_2040_n1	80	2010	Solde naturel, entre 1999 et 2006

TASK 3 : RECENT COMPUTER TECHNOLOGIES FOR AN INNOVATIVE CARTOGRAPHIC LANGUAGE

Review the state of the art in recent computer technologies and related cartographic software in support of ensuring an innovative cartographic language.

The service provider is asked to review the state of the art in recent computer technologies and related cartographic software development in support of ensuring an innovative cartographic language. The service provider shall, based on this review, present options for modernising the ESPON Cartographic Language.

The fulfilment of this task should not be limited only to more "traditional" cartography, but explore new options for adding new cartographic concepts, types of illustrations and computer animated presentations, that could support the presentation of the geography of policy orientations and forward-looking territorial evidence to the European territorial policy arena. The review shall lead to recommendations of cartographic technologies and techniques to consider in a modernised ESPON Cartographic Language. It shall be used as input for recommendations on new cartographic elements to consider in a modernised ESPON Cartographic Language under task 4 and 5.

Three dimensions for an Innovative cartographic language will be explored in three directions:

- *Former Semiotic language combined with new technologies*
- *Usability of the produced representations*
- *Focus on added dimensions like interactivity, animation, multimedia, 3D, etc.*

Introduction

The 1980s, with the exponential development of computer technologies, provided several sources of renewal for cartography. But as noted by numerous authors (Jégou 2006, Cauvin 2008) it had more effect on the usage made of maps and on links between cartography and other disciplines than on innovations in the area of semiology as such. What has been seen is the development of exploratory uses of maps, and the arrival of cartography in the discipline of exploratory analysis (Tukey 1977) and the visualisation of scientific information (VISC) (Tufte 1983). Thus the last 20 years have seen the appearance of a new paradigm, that of geo-visualisation, which is based on the development of methods for exploring and visualising data, and which has gone hand-in-hand with the arrival of micro-computing. This has been accompanied by the spectacular development of digital geographical information and geo-localisation techniques.

Although the recent period has not been characterised by particularly remarkable evolutions in cartographic representation and semiology, there have been changes in the positions occupied by cartography and cartographers, among which the following:

- there is no optimal map (MacEachren 1995) and the reader should be stimulated : the map is a tool generating thought (visual thinking)

- there is no objective representation (the cartographer adopts a stance) and the trend is towards multiple representations

- there is a reconciliation between two opposite positions, that of cartography as an art, and that of cartography as a science (Keates 1989, Robinson 1952) . After an alternation of these two positions, today an integration of the two approaches can be seen – cartography as a science focuses on analysis of spatial patterns, while at the same time producing visually pleasing representations of that information

- with the appearance of exploratory usages of maps, the user is placed in the centre of the cartographic production, and an interactive "user-map" model has appeared (MacEachren 1995).

In this section we therefore propose an illustrated exploration of these recent developments, mainly on the subject of technological environments and the introduction of "user-map" interaction, which have both fundamentally altered the use of cartography. This analysis makes reference to the three-dimension model proposed by MacEachren & Kraak (Figure 3.1) which places cartographic production between visualisation and communication on the basis of three dimensions of map usage:

- the type of audience – private or public

- the state of knowledge – from revealing "unknowns" to presenting "knowns"

- the level of user-map interaction – high to low

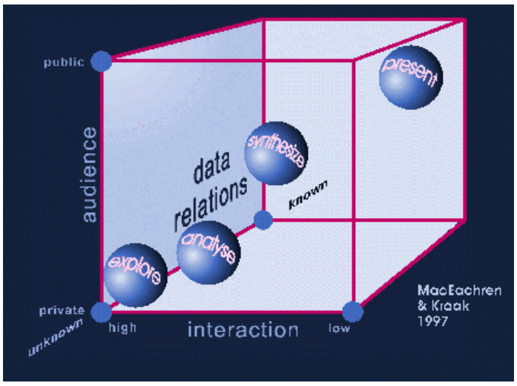


Figure 3.1: The different maps uses according to three dimensions

We therefore propose a review of the different developments and their workings within this new trend formed by interactive and geo-visualisation cartographic environments. It should be noted that this change in paradigm is nevertheless a continuation of the work by several cartographers and of several emblematic cartographic styles – these environments include the exploration of what Bertin called "typical questions". And it should not be forgotten that the map produced by Dr. J Snow in 1854 enabled exploration of the causes of the spread of the cholera epidemic, nor that Minard's map published in 1969 is still today one of the emblematic "narrative graphics" in visual analytics approaches.

Web and multimedia technologies enable the development of a wide range of cartographic applications, from simple visualisation techniques for geographical data to environments for developing geo-visualisation interfaces or geographical information systems (GIS), and including applications such as those for exploring multi-dimensional and multi-level data. These different types of map enable users to perform thematic, spatial, exploratory and visual analyses.

We therefore intend to review different aspects of these applications in interactive cartography, where territorial atlases are prominent and will be used as illustrations. We will first present the characteristics of these new geo-visualisation environments centred specifically on "user-map" interaction: first the characteristics and the scope provided by interactivity, the logics of its implementation for exploration, and the specific features of environments integrating temporal dynamics. Then we will consider a few specifically cartographic innovations, and the potential of these developments. Finally we will make a rapid presentation of the technological aspects of these environments, and introduce new practices known as "volunteered geographical information" which are at present gaining a considerable audience.

The analysis we present hereafter is based observation extending beyond that of the territorial atlases alone. However these atlases provide a sample that reflects the variability of modes of representation and interaction, and the many technologies in the domain. Thus the analysis will be illustrated mainly with examples from this type of application.

1. The new characteristics of geographical information and the increasing complexity of cartographic representations.

1.1 Increasing amounts of geographical information

Recent advances in information systems, in particular in data storage, data capture, mobile technologies, internet and also geographical information processing, have contributed on the one hand to an accumulation of geo-localised geographical information over time, and on the other to "democratising" production and access. Data in digital form is accumulating exponentially – indeed in the last 5 years more data has been generated than humanity had gathered up to then (Keim & all 2005)

There are today numerous databases containing geographical and geo-localised data that can be used for maps. The following can be distinguished:

- spatial databases, which contain data on the geometry and localisation of objects on the Earth's surface (buildings, communication networks, individuals, geographical zones, hydrographic networks, relief, vegetation, etc.).

- territorial databases, which provide various types of information on the scale of a socio-economic territory (region, city, country etc.): geographical information corresponding to the outlines of territories, statistical data, localisation of services, regulatory documents, mobility data, measures, transport, electoral data, health, economic, demographic and urban data.

- environmental data, covering all the observation data relating to environmental issues.

These databases as a whole afford opportunities for the analysis of socio-spatial or spatio-environmental phenomena – study is conducted on behaviours, sociological dynamics, regional and urban dynamics, relationships between societies and their environments, and so forth.

The wide access to positioning devices (GPS) and smartphones, alongside Web 2.0, has contributed to a spectacular expansion of geographical data. Smartphones and GPS trackers make it easy to read the positions of individuals or objects, whether or not they are mobile, on the surface of the Earth. It is now far easier to obtain information at individual level. This opens new perspectives for analysis – the study of individual movements, their daily activities, trajectories of objects and individuals, social relationships, etc.

The geographical Web, or GeoWeb, has become the main way to store, publish, share and disseminate geographical data, developing the Volunteered Geographical Information concept which enables Web users to become active "voluntary contributors" in the processes of producing geographical or geo-localised information. OpenStreetMap is representative of this "volunteered" production of geographical information.

Because of the diversity and the on-going evolution of tools and methods of production and processing, this data is heterogeneous, imperfect, multi-level and multi-dimensional (figure 3.2).

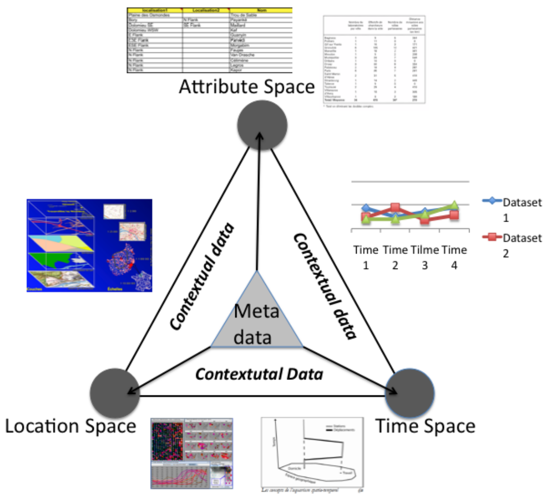


Figure 3.2: The main characteristic of geographical information
Source: Kraak, 2011

Geographical information integrating the temporal dimension

With the accumulation of data over time, and the efficiency of the data collection systems that we have at our disposal, we now have numerous time-series concerning localised territorial, socio-economic and environmental indicators. We also have geographical databases containing information referred to as geo-historical, concerning past territorial and environmental phenomena (such as floods), or information derived from earlier cartographic forms, so that changes in territories or geographical areas can be followed over time. Geographical information now has a temporal dimension (dates, durations) which also needs to be integrated into cartographic production.

This data enables the study of the dynamics of territories and socio-spatial phenomena. There is increasing interest in the expansion of cities, the evolution of growth and demographic indicators, changes in landscape, land use, the spatial dynamics of environmental phenomena (such as pollution, climate and vegetation), individual mobility patterns, and, generally, phenomena in space in relation to time.

Multi-scale geographical information

Given the wealth of data available, the temptation is to try to relate this data via cartographic representations, so as to deduce structures, dynamics and spatial relationships. However the data, which is derived from various sources, and produced at different periods for different purposes, is characterised by a wide diversity of scales of geographical observation, from global (continent, cultural area, geographical area, nation) to local (city, city district), and including the regional level, as well as wide temporal diversity (yearly, monthly, daily periods, and frequency of observations). This raise the question of how this data can be related, in particular when the geographical grids are heterogeneous and do not provide perfect hierarchy, or when frequencies of observation are not homogenous or continuous.

Information on the quality of geographical information

Geographical information has become a mass product handled by users who are not all experts. It is therefore liable to numerous errors of interpretation and analysis. In information or decision-making settings, it can be wise to also provide for assessment of data quality, information on the context in which it was produced, and how it is intended to be used and interpreted. This quality dimension is particularly important in geographical information. However quality assessment is not simple, and can take different forms: quality indicators (Devillers, 2004), informational elements (texts, documents, photographs), or meta-data.

Cartography is growing increasingly complex

Today, are cartographic production methods suited to the new characteristics of geographical information and efficient in responding to the new needs that are arising? Are they, in fact, able to take account of different criteria, such as:

- the volume of data – how can several large datasets be represented on a map without cognitive overloading?

- the temporal dimension: how can evolutions, chronological series of spatial data, recurrent phenomena or changes and shifts be represented? or else evolving data, that is to say geographical objects whose configuration changes over time? or heterogeneous, non-structured geo-historical data to that are attached other types of information (photographs or texts)?

- the quality of the data: how can information be obtained on the quality and the characteristics (sources, modes of production etc.) of the data?

Conclusion

Web and multimedia technology have generated new ways of publishing geographical data. They have also widened the scope for cartographic representation and expression, so that the changes in the characteristics and the usage of cartography can be taken into account. The map has become interactive, multi-media and dynamic. It has moved from a paper base to an electronic display, and has integrated ever more complex computer applications. There is today a wide range of cartographic applications for a wide range of purposes, from localisation or visualisation of geo-localised information to the analysis and exploration of multi-dimensional, multi-level information using geo-visualisation computer environments. Whatever the objectives, user-map interaction is at the heart of these systems.

2. Interactivity: a revolution in cartographic uses

One of the first innovations in the area of the cartographical applications developments provided by the new Web and multimedia technologies was the development of interactive atlases.

Classically, a cartographic atlas is seen as an ordered ensemble made up exclusively or mainly of maps that may be geographical, historical and so forth. More generally, an atlas is a collection of maps designed to represent a given territory and deal with one or several themes. With the functionalities provided by computing, and in particular its interactivity, multimedia, and the links to geographical information technologies (spatial databases, GIS), interactive atlas, have contributed to new forms of cartographic visualisation. They offer the user the opportunity to discover a territory, and to consult geographical information and phenomena actively and interactively (figure 3.3)

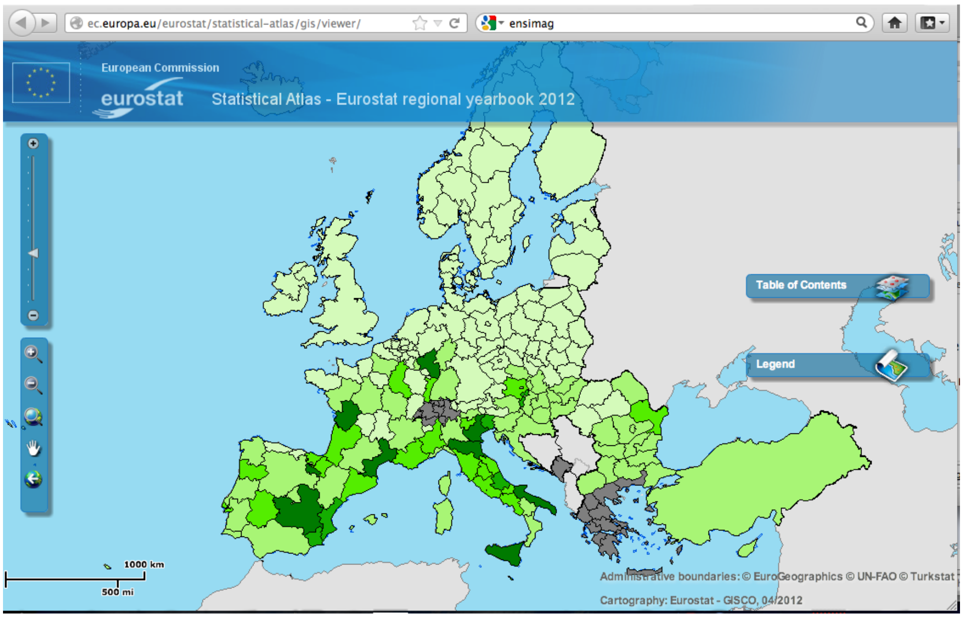


Figure 3.3: Example of Interactive Atlas: Statistical Atlas of Eurostat
Source: http://ec.europa.eu/eurostat/statistical-atlas/gis/viewer/

With the Web, using maps has become more accessible. Users have diversified and are no longer all specialists of geographical information or cartography. The Web has placed the user in the centre of the map production process. With it, the concept of « maps-on-demand » has developed: a map can be produced according to the needs and wishes of users, or can be adapted to customized cognitive representations. Displays and visualisations are tailored to user specifications.

The environments are nevertheless fairly complex. Firstly they need to integrate elements making up the cartographic documents, and that enable the interpretation and reading of the map (legend, orientation, scale etc.). In addition, the concept of maps-on-demand requires interactivity between user and cartographic application, but also non-sequential access to the map (Cauvin, 2008). Thus, using the different tools or functionalities, the user can navigate at will among maps or layers of geographical information, select the variables to be mapped, alter appearances or graphic styles, and access multi-media information (texts, photographs, images), thus providing a complementary description of the objects being mapped (figure 3.4 & 3.5)

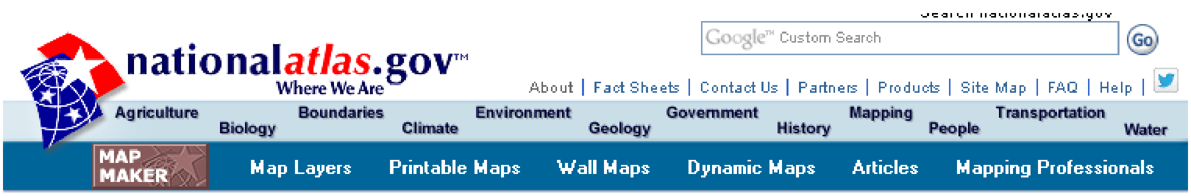


Figure 3.4: example of an atlas offering different cartographic services: Map maker, map layers printable maps and dynamic maps

Figure 3.5: Various services offer by interactive cartographic atlas: the Atlas of the World
Source: http://www.worldatlas.com.

Interactivity is defined as a process of exchanges between two actors. In computer science, interactivity can be defined as the set of tools (keyboard, mouse, pointer etc.) and functionalities that are accessible via an interface enabling a user to communicate with a computing system. In a cartographic, it is the map that is the interface. If it is well-designed, this cartographical interface can enable access to data and information that will be capitalised by the users.

2.1 Interactivity tools

In the interactivity process the mouse is a central element between the user and the computer. It is with the mouse that the user can select a point on the map, or data, or maps, or access zoom or other tools. Among the tools used, we can distinguish *selection tools*, *navigation tools* and *positioning tools*.

Selection tools

They allow the user to select the cartographical information to be displayed. Several selection modes can be offered – selection using CheckBox or radio buttons activated with a mouse click, selection in a scroll menu, textual selection, selection via predefined tabs, and selection via a click on the map (figure 3.6).

- CheckBox selection: the user can display / hide a succession of maps by activating/deactivating the CheckBox, corresponding to the data selected.

- selection in a scroll menu: the user selects an item from a predefined list. These items can correspond to a list of variables to be mapped, a list of themes that the user wishes to focus on, or the selection of a study territory, a geographical grid, a cartographic scale etc.

- textual selection: the user can capture a text in a publishing field (for instance the name of a city, or a number representing geographical coordinates or post codes). For instance, this type of selection enables the required geographical localisation to be positioned directly on the map.

- selection using the mouse on the map: A mouse click on the map gives access to further information relating to the element selected on the map (object, place etc.). The selection can concern a point or a zone. In the second instance the selection is performed using a rectangle or a polygon enclosing the element on the map using the mouse.

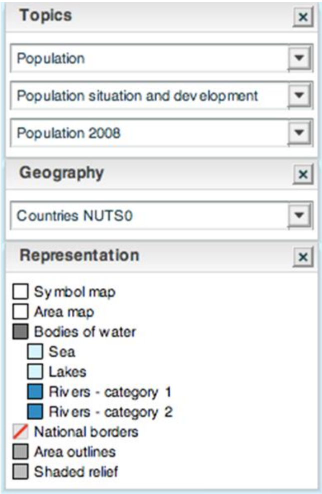


Figure 3.6: Select Tools in the interactive cartography atlas
Source: Statistical atlas of Switzerland

Navigation tools

These enable the user to move across the map using the mouse, or to move the map so as to get a view of all its parts. The movements of the mouse tracker, and pan and zoom effects are the basic tools that characterise interactive environments in cartography. In a 3D interactive environment, or one offering orthophoto, DEM or satellite imagery visualisation, flyover will complete the range of tools (figure 3.7).

- moving the mouse across the maps has the effect of highlighting the elements over which the mouse is positioned. The passage of the mouse on a place on the map or elements in the application interface enables contextualised display of information in the form of *tooltip* (i.e. display of the name of the object over which the mouse is positioned, or of descriptive information). In the case of dynamic links between the different windows or components of the interface, the highlighting will be applied to all the elements linked to the given object. If the map is linked to other maps (for instance created via dynamic display) the highlighting will favour the comparison of a temporal or non-temporal series.

- the *pan* is a function that enables "progressive translation of the map", enabling the user to go up and down, and right and left over the map. It means the user can see parts of the map that are not initially displayed on the screen.

- the *zoom* enables enlargement (zoom in) or reduction (zoom out) of a zone on the map. It enables a selected object or zone to be seen more precisely, or an overall view. Several types of zoom are distinguished: static zoom which entails no change in content and amounts to a straightforward geometrical alteration (enlargement or reduction); dynamic zoom (also called semantic zoom) corresponding to a change in cartographic scale or level of generalisation, which alters the shape of objects, and give more details. This tool has introduced the concept of "Detail of Demand".

- *full-extend*, which enables an overall view of the geographical space considered

- *flyover*, which mainly concerns interactivity with orthophotos, or aerial views or virtual cartographic environments. Flyover enables the user to have a 3D view of the image, and to move above a landscape (Google Earth).

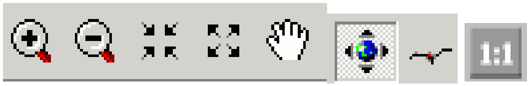


Figure 3.7: Navigation Tools (Zoom in/out; Pan: Overfly; full extend)

Situation or positioning tools

These enable the user to position him/herself on the map being visualised.

Two types of tool are generally on offer:

- the geographic cursor, which enables the user to obtain the geographical coordinates or identifiers (name, code etc.) for a given point

- the reference map, usually located in a little window, which enables the user to locate the zone being visualised in relation to the overall geographical space integrated into the application. As the screen has a defined dimension, the space visualised on the screen is only a sub-space of the mapped space (figure 3.8)

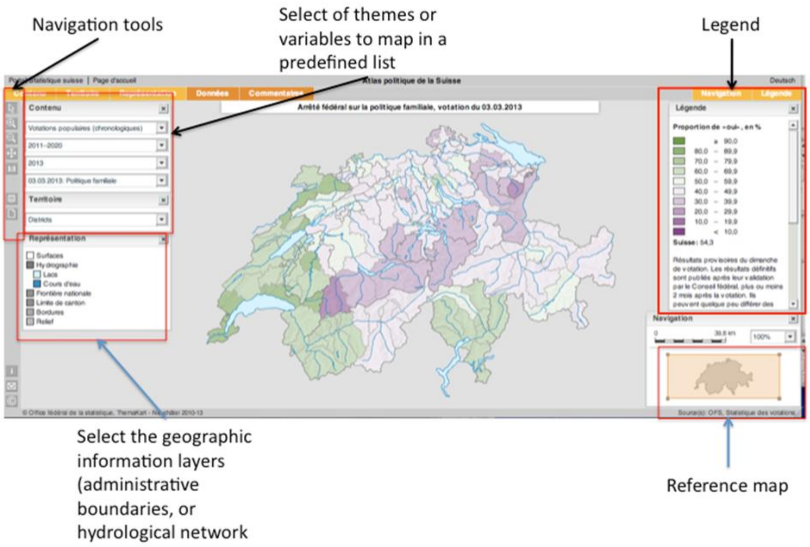


Figure 3.8: Main interactive tools into the cartographical interface
Source: Statistical Atlas of Switzerland - www.statatlas-schweiz.admin.ch)

2.2 New interactive maps

Interactivity has thus provided new opportunities in terms of map production. New map forms have appeared, such as "*clickable" maps, multimedia maps, hypermedia maps, animated maps* and *dynamic maps*. These different cartographic forms are connected with the introduction of interactivity and multimedia, but also on dynamic links that are integrated into the cartographic tool. They also depend on how much movement they provide for. *Static maps*, or collections of static maps become *clickable maps* (Kraak, 2001), if they can be associated with quiered or selected with a mouse click. They become *multimedia maps* if the hyperlinks associated with cartographic objects display information presented in different forms (image, text, photograph, and video). *Interactive maps* can be clickable or multimedia maps (figure 3.9). Maps that integrate movement are referred to as *animated maps* which evolve into *dynamic maps* if the user can also interact with them. If the interactivity also makes it possible to consult other media, we refer to *dynamic multimedia maps*.

Figure 3.9: A multimedia map

Source: http://www.nationalatlas.gov/dynamic/dyn_vol-wa.html

These different cartographic forms can be integrated into a single cartographic environment, thus forming, for example, an electronic cartographical atlas. This can be dynamic if it comprises dynamic maps, and/or multimedia if it comprises multimedia maps.

The main characteristics are that the environment enables the following:

- progressive consultation of data, from overall view to detail (Details on Demand)

- development of maps-on-demand – users can adapt the maps according to their knowledge of the subject matter so as to understand the information at their own pace. Interactivity improves the understanding of phenomena by way of hyperlinks.

- the integration of complex, non-structured heterogeneous data: associating hyperlinks and hyperdocuments with the geographical entities generates hypermaps. This process enables non-sequential navigation of the map via indexation of a point on the map towards other cartographic documents or other layers of geographical information.

2.3 Different levels of interactivity

Interactive cartography software can be distinguished according to their level of interactivity. Cauvin (2008) distinguishes the *level of control* corresponding to simple consultation and navigation across a map, from *complete interactivity*, usually restricted to use by experts and providing numerous possibilities for manipulation, and even the construction of scenarios.

- the most elementary type of interactivity, observed in the new interactive environments, consists in enabling the user to intervene solely **to display or hide the map** or to navigate on the maps (panning or zooming in and out), to access to the geographical position of a selected point or geographical objet, and to select objects on the map using the mouse, or selection via tabs or scroll menu (figure 3.10).

Figure 3.10: Elementary consultation of the maps in the Altas of Canada (Toporama)
Source: www.atlasducanada.com/site/english/toporama/index.html

- the second, intermediate level of interactivity offers, in addition to the elementary functions, the possibility of changing **the cartographic semiology** (figure 3.11 & 3.12).

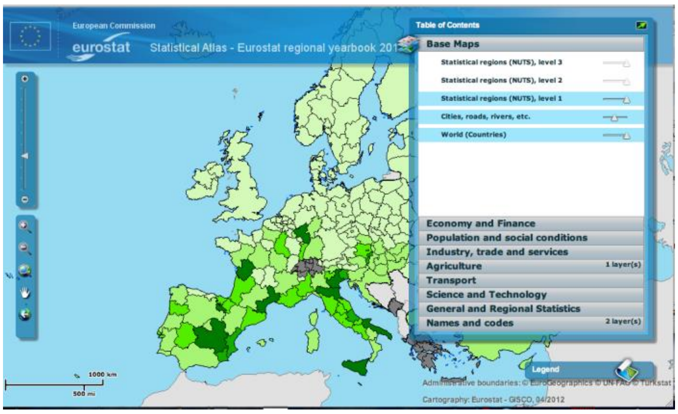


Figure 3.11: modifying the appearance of the maps: Statistical Atlas of Eurostat
Source: http://ec.europa.eu/eurostat/statistical-atlas/gis/viewer/

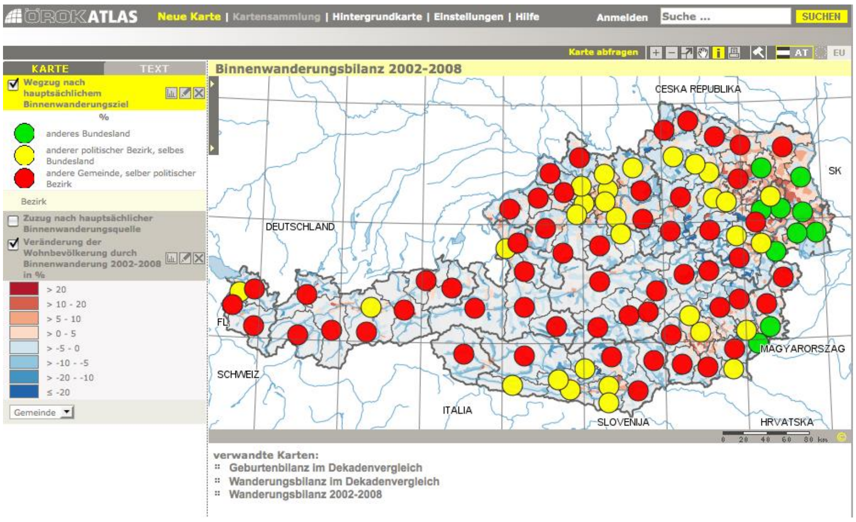


Figure 3.12: modifying the appearance of the maps: Atlas of Austria
Source: http://www.oerok-atlas.at/gui/map.php.

- another level of interactivity consists in offering the user the possibility of **modifying the thematic data**, or constructing scenarios, by selecting data, linking them,–applying statistical or mathematical methods, and taking into account the context of data (figure 3.13).

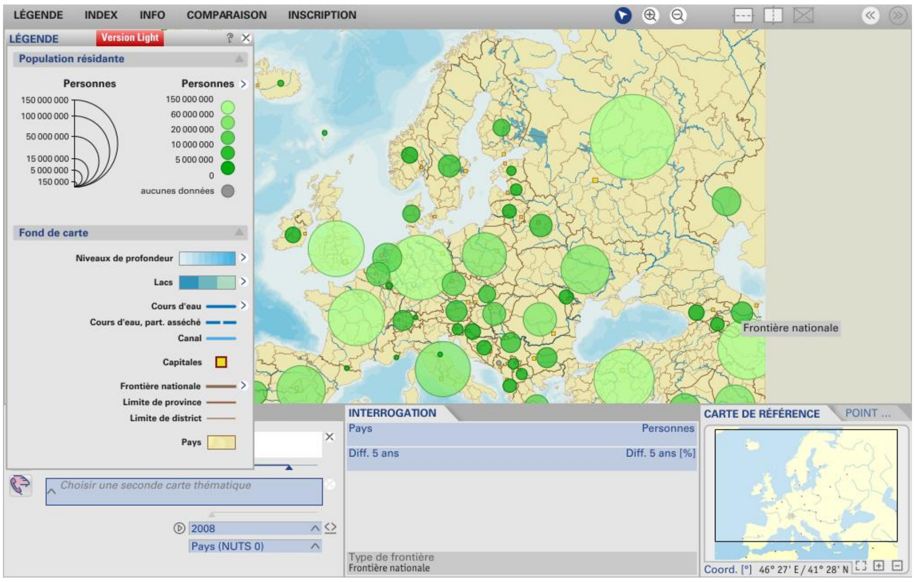


Figure 3.13: Atlas of Switzerland offers various functionalities to allow the user to build scenario
Source: www.statatlas-schweiz.admin.ch

The first levels of interactivity mainly concern the map itself. It is what certain authors refer to as internal interactivity (Adrienko & al, 1999). The higher levels of interactivity involve dynamic links between software components, in particular databases. Via interactivity, maps are no longer designed to be merely graphic representations of geographical space, but as dynamic interactive portals providing resources in the area of geospatial data (MacEachren & al, 2001).

2.4 Interactivity functionalities: manipulation and exploration

We are talking here about functionalities that are specific to the interactive cartographic environment, the purpose of which is to enable the user to identify the spatial characteristics of the phenomena mapped. Using the different functionalities provided, the map had to address the primary issues: Where? – where is this or that element located? – and What? – what is the meaning of this or that object or set of objects? These functionalities are defined according to the objectives and the needs of the user. They rely on the use of selection and navigation tools available as described above, and also on the cartographic or statistical processing integrated into the cartographical applications. Different types of functionality can be distinguished: those linked to display, those linked to representation, and those linked to searching for information.

Functionalities concerning Cartographical display

The selection tools described above offer the user the possibility of choosing the themes and variables to be mapped. The elements selected are displayed like geographical information or map layers. Geographical information layers correspond to spatial data (administrative boundaries, regional boundaries, hydrographic networks, geographical areas, infrastructures, satellite images, ortho-images etc.) (Figure 3.14). The map layers correspond to graphic expressions (symbols, colours, shading etc.) used to represent the information that is attached to the spatial data. The data is represented in the form of choropleth maps, of map with proportional shapes (circles), or as inventory maps (with pictures symbols)., colored maps, maps with multivariate pie chart diagrams... The display is based on some principles:

- overlay of geographical data according to the principles applied in GIS. The idea is to enable display simultaneously, in one and the same map, several layers of information geographic or map layers linked to different themes and different variables (figure 3.14)

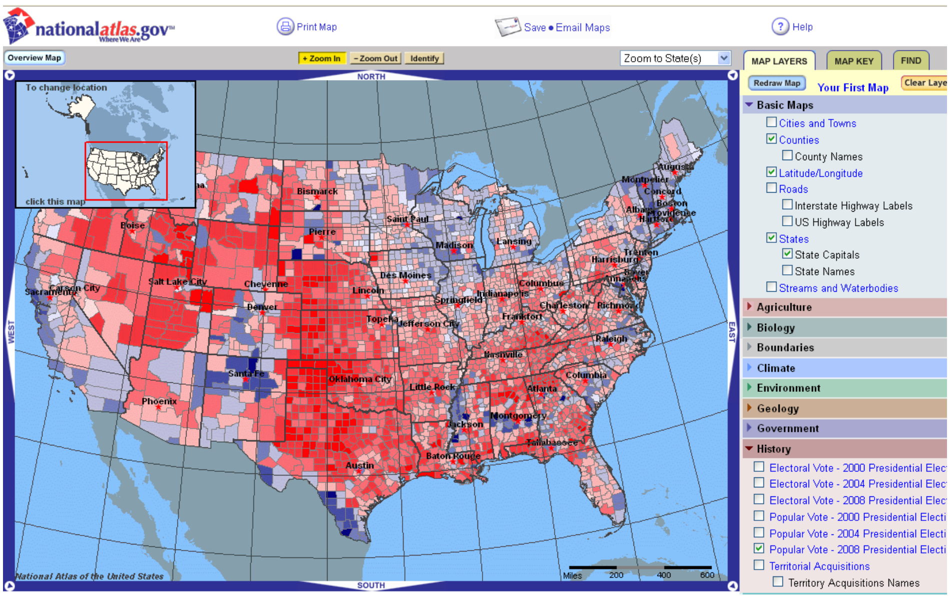


Figure 3.14: Multilayers in the national atlas of United States

Source: www.nationalatlas.gov

- progressive display of layers of information on the map: according to the degree of zoom or the geographic scale selected, some layers of information will be displayed or not on the map. This process also applies to the variables and themes to be mapped. The choice is generally made by the user, either for reasons of availability and relevance of information (certain information may be available but only meaningful on a certain scale), or for reasons of cognitive overload.

- the modification of the content of the information layer according to the zoom or the level of geographic entity selected. In these cases the user can obtain more detail on both the geometry and the semantics of the geographical objects. The zoom can correspond to a change in scale, and involve a change in the geometry of the representation of the object – change from point or line to polygon, depending on the zoom (figure 3.15).

Figure 3.15: The same information displays according different levels of semantic zoom
Source: IGN Portal- http://www.geoportail.gouv.fr/accueil

Functionalities connected with cartographic representation

These offer the user the possibility of acting on the visual aspects of the map (figure 3.16):

- by changing the visual variables initially provided (choice of colours hue, symbols, symbol size, shape, graphic textures etc.), thus changing the semiological characteristics and the graphic expression of the map

- by playing on transparency, the user can improve the visual aspects to suit his/her needs

- by acting on indicators required to comprehend the map: addition or removal of labels on the map indicating place names or the values of the variables mapped.

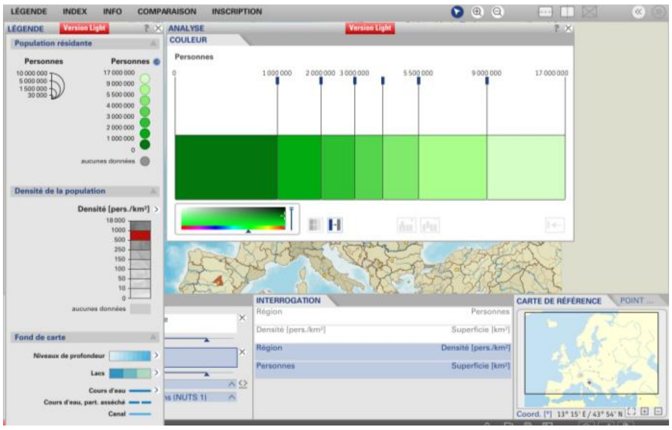


Figure 3.16: Modifying the cartographic representations
Source: Atlas of Switzerland- http://www.swisstopo.admin.ch/internet/swisstopo/fr/home/products/atlas/ads.html

Some applications as Atlas of Switzerland, propose also 2D, 3D or panoramic views (figure 3.17)

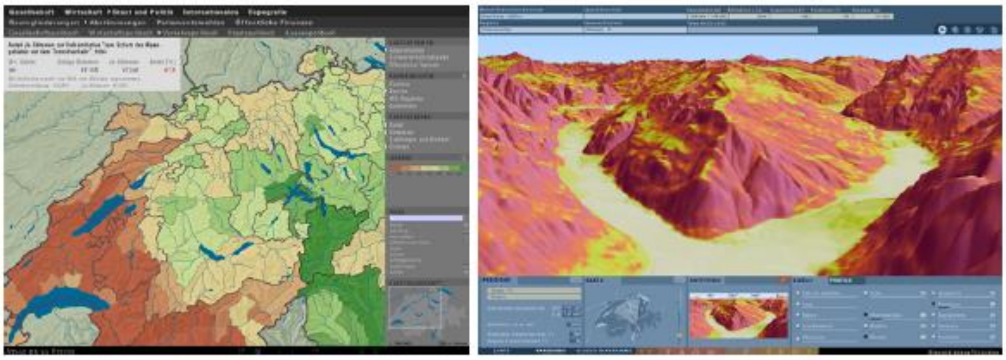


Figure 3.17: Atlas of Switzerland: Map 2D (left); 3D (right)
Source: Sieber & al, 2009

Search functionalities

They offer to the user the possibility to query using the select tools. Different kinds of queries are proposed: textual queries or visual queries using the click of the mouse. The user can make simple queries or multicriteria queries. Usually, the result of the query is displayed on the map, (or on the graphic) by highlighting the searched objects (figure 3.18 &3.19).

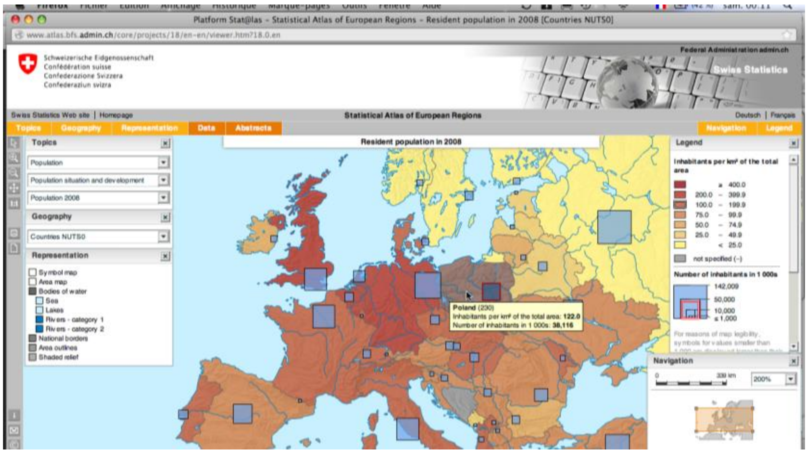


Figure 3.18: Visual queries in the Statistical Atlas of Switzerland
Source: www.statatlas-of-europe.admin.ch

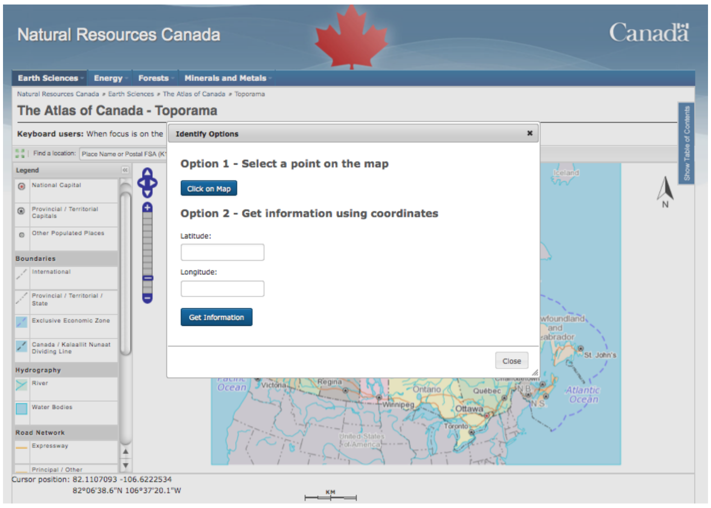


Figure 3.19: Example of search functionalities
Source: Atlas of Canada - http://atlas.nrcan.gc.ca/site/english/toporama/index.html

2.5 Interactivity and the particular role of the legend

In an interactive cartographical environment, the place of the legend is as important as it is in static maps, and requires care with regard to both design and display. Usually, the legend is integrated into the map (figure 3.20).

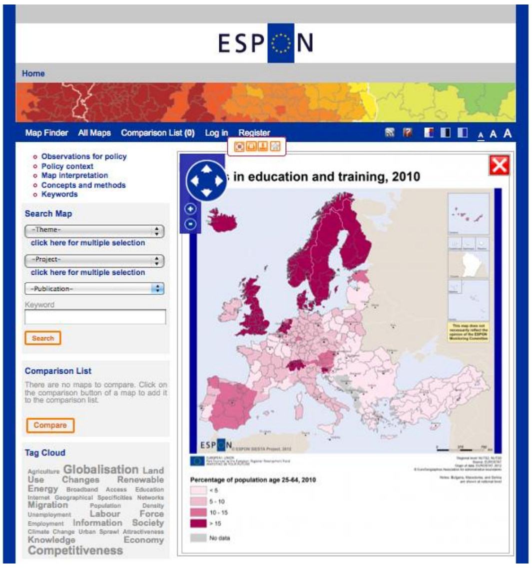


Figure 3.20: ESPON Online Mapfinder

But more and more, in the applications, the conception of the legend is based on cartographic rules. For its display, the legend is presented in a separate window, positioned beside the map, but it can be displaced, or removed from the map. The legend is interactive and dynamic: It is directly linked to the map (and sometime to other components of the application).

The legend has a specific role:, it enables identification of elements on the map, the display of the information to be visualised, and it also enables information to be searched for. It is of course with the legend that the user can modify the semiology of the map (figure 3.21).

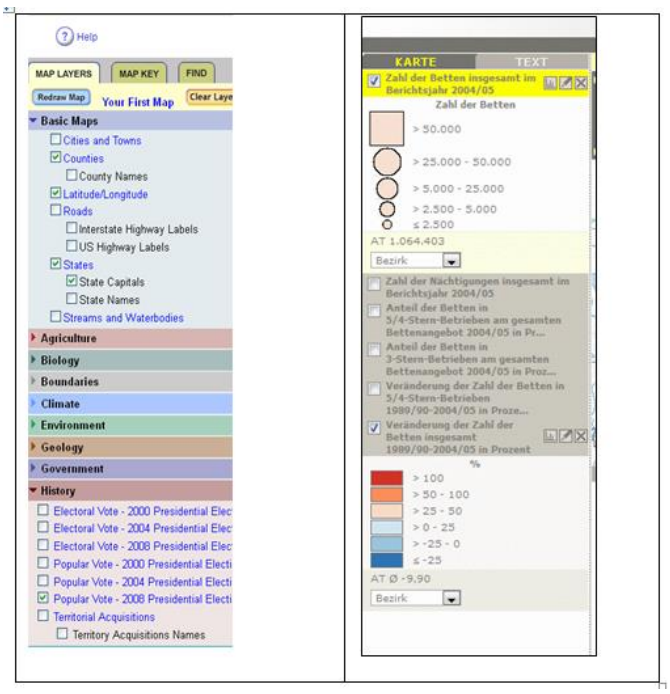


Figure 3.21: Examples of interactive legends: (left) Atlas of United State; (right) Atlas of Switzerland

Conclusion

Thus interactivity has become a central element in a map, and it has modified the user-map relationship. The user is no longer a "reader" of the map; he or she is also designer. Interaction enables the user to adapt content and cartographic expression to his/her needs desires and cognitive representations. In association with the new information and communication technologies, interactivity has generated new types of map: interactive, multimedia or dynamic, thus enhancing the possibilities for representation of geographical information. However the opportunities offered by interactivity extend well beyond these new forms of cartography and maps-on-demand. It has also opened up the field for the exploration of geographical data, thus enhancing the visualisation and analysis potential of maps.

3. From interactivity to exploration and analysis

Maps, considered as vehicles for communication, have undergone the same evolutions as communication means as a whole, and they are now more and more integrated into systems of "visualisation", where one of the main principles is that numerous views of the information (cartographic or graphic) are offered.

Going beyond mere interactivity, we are looking here at cartographic applications for analysis and exploration of geographical information. These applications belong to the area of geo-visualisation, which provides a new horizon for geographical data and territorial analyses. Cartographic representations are still as the heart of the system,, but the environments used enable not only the localisation of data, but also exploration and synthesis of that data on the fly.

Numerous institutions have opted for the development of interactive atlases integrating this exploratory dimension. Unlike environments dedicated to “maps for presentation”, in exploration environments the map's "story" has not yet been drafted: generally the user is given the means to focus on his or her own dataset, thus enabling the drafting of his/her particular "story", casting his/her own light on the phenomenon by way of data exploration tools: exploration environments enable numerous levels of interpretation, and a contextualisation of data according to several different dimensions, even enabling the construction of scenarios.

We return here to the technical characteristics of these applications, so as to present their usefulness, illustrated by examples from different territorial atlases. In this part we will not touch on the temporal dimension, which will be approached in the following section.

3.1. Exploration tools

Interactivity and dynamic links

All the applications are based on the principle of user-interface interactivity. This is one of the meanings attached to the term "dynamic" when we refer to a "dynamic cartography application". The actions of the user on the interface change the aspect of the map.

In applications that offer explorations, it is also the link with the database that is referred to as dynamic. The map is the interface that enables exploration of the database: the objective is no longer merely to "localise", it is to explore the links between different indicators and the space considered.

The types of application or interactive atlases can be hierarchized in three categories:

- those presenting maps and data

- those that add the use of dynamic filters

- those that add graphic elements

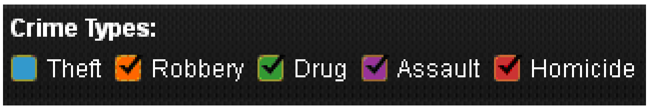
Multi-selection of entities

The selection of entities will enable either the specificity of the organisation of a particular subset of entities to be targeted, or its specific attributes. In most applications, these entities can be selected:

- via the map – here we find the tools already described, selection arrows in circles or squares

- via an entity belonging to an upper geographical level: systems can integrate for instance the hierarchies of administrative zonings; by selecting an entity belonging to a higher level, it is all of the elements making it up that are selected, for instance all the *communes* in the Provence-Alpes-Côte d'Azur region, or as in the OECD application, all the regions on the country "Sweden".

- via an attribute filter: the most direct filter is that applying to classes in the legend, which enables isolation or removal from the map of entities with values corresponding to the colour code selected or de-selected.



This type of filter is particularly well-suited to classes (nominal or ordinal variables) when they appear on the map.

However certain applications make it possible to do away with these classes, using a form that enable specification of the filters to be applied to numerical or alpha-numerical variables (Figure 3.22).

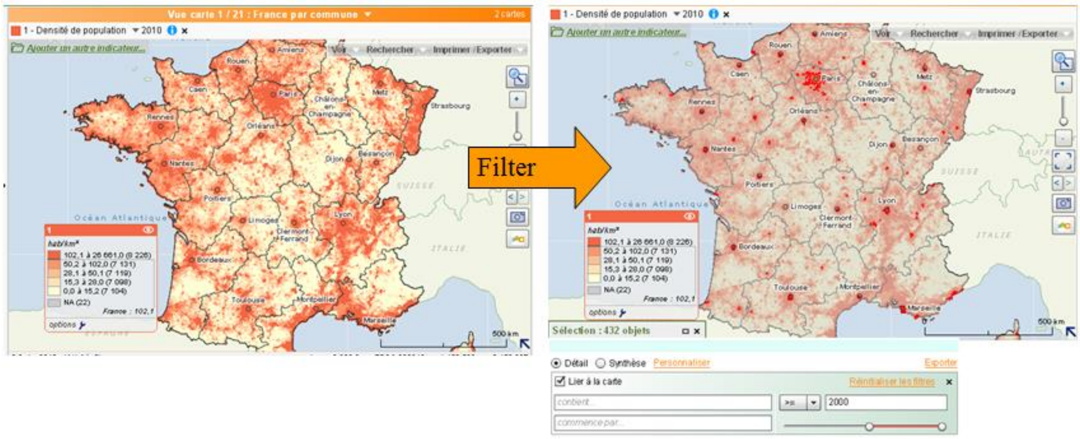


Figure 3.22: Example of filter via data query: Map of French commune densities (left) and selection of communes with density higher than a given threshold (right).
Source: http://carto.observatoire-des-territoires.gouv.fr

Multiple views

The main innovation of these applications resides in their links with data. Here the task is not to "publish" maps on the Web or to use the scope offered by multimedia for the user to view places. Here the user is given the ability to construct an exploration model via a link between the spatial organisation and the statistical distribution of the phenomenon observed. As in "scientific visualisation" applications, the map occupies one window, and other windows serve to provide different views of the statistical distribution represented, or even links between the distribution represented cartographically and other indicators.

The most well-known and the most extreme environment is probably the application developed for OECD (OECD Explorer), where the map is just one window among others (figure 3.23). A set of graphic windows provide information on the entity itself, its relative position in the statistical distribution, its profile in relation to the set of indicators chosen, and on relationships among all the different indicators. Statistical and geographic views are linked together: one element selected in one view, is simultaneously highlighted in the others.

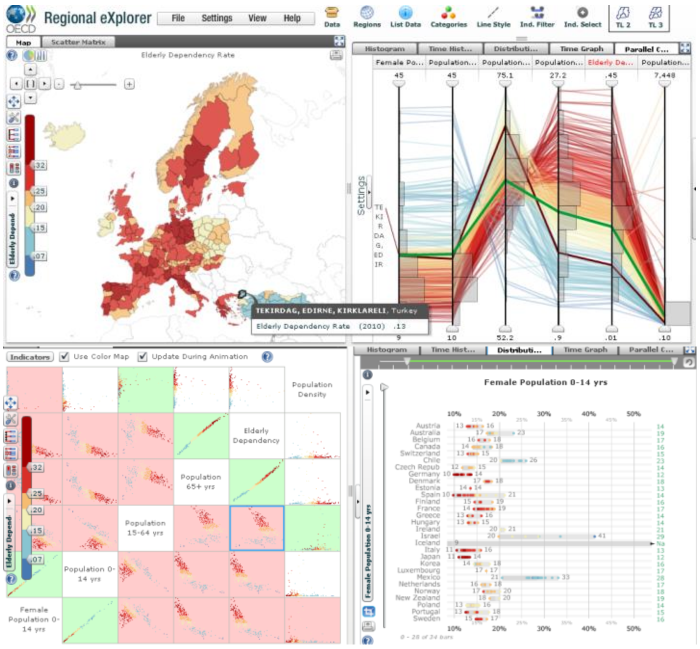


Figure 3.23: Multiple views of the same data combining spatial distribution and statistical distribution in the regional
Source: eXplorer atlas of OECD.

These environments generally provide suitable graphic representations, enabling numerous views so that the entity can be positioned in the distributions, and comparisons can be made of the distributions one to the other. The design is intended to facilitate "visual thinking". These tools should « take advantages of human vision, our propensity to categorize, and standard schemata for judging similarity and difference along with a semiotically robust sign system that facilitates the perceptual/cognitive process involved" (MacEachren 1995)

3.2. Exploration functions: contextualisation

The added value of these applications resides in their ability to cast new light on the entity observed, which is not possible with a straightforward cartographic representation. Further to this, linking a map dynamically to other representations of the data in the visualisation interface places the statistical distributions of the indicators used at the heart of the representation, so that it is easy for the user to return to them. Thus the philosophy of exploration is very different from that of cartography – if only because there is not just one cartographic representation. In addition, the notion of contextualisation is essential in exploration environments. All the tools available for representation, because they are have dynamic links with selection tools; enable numerous views and different light to be cast on sub-sets of data. They enable great flexibility for apprehending a map and reading spatial organisations on several levels: global, intermediate and local, as suggested by Bertin (1983).

Selections enabling identification of specific spatial configurations

Filters and selections enable categories of entities to be isolated, and the analysis of specific distributions. This is impossible when the entities are numerous and distributions not spatially auto-correlated. Most often, these functions are first of all used to isolate spatial organisations with extreme values, and then one by one to compare different organisations, and possibly to construct a mental model of the organisation of certain values, or of the whole.

This approach consisting in analysing distributions one by one according to categories, specific to exploratory analysis (Tufte, 1983) recalls Bertin's idea (1983) in favour of using "small multiples" (figure 3.24) on composite maps where the eye can often only perceive concentrations and empty spaces, and cannot isolate categories according to symbols. This goes against the line of research aiming to reflect spatial organisations in synthetic manner using univariate processing methods. These two positions are emblematic of the two extremes of the line describing the different uses of the map in the cube presented in the introduction (MarEachren): exploration vs presentation.

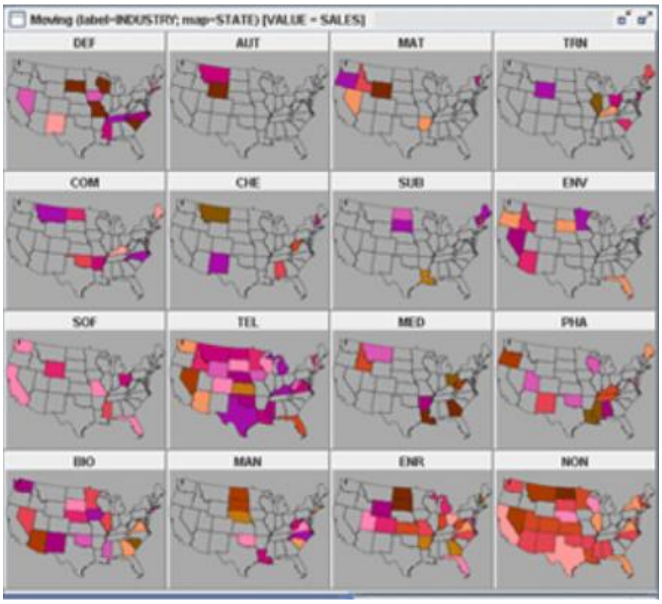


Figure 3.24: Small multiple maps instead of synthetic map
Source: http://www.spatialdatamining.org/software/visstamp

Selection for local reading in a global context

One of the issues concerning thematic maps is that of positioning an entity in relation to the distribution of the values for all the different entities. The map alone can answer this question. But then there is the question of the position of the entity for the linked indicators. The user then seeks to establish links and set out hypotheses. Figure 3.25 illustrates this type of contextualisation: the map shows the distribution of female mortality from leukaemia according to the region in the UK. Selecting a region give access not only to the value for this region for the variable mapped, but also to other indicators. We are here broaching the notion of the "statistical profile", while retaining close links with the data. Certain systems also enable values for entities to be positioned in relation to the distribution as a whole. This is the case for the National Cancer Intelligence Network, which uses the profile to pinpoint values that differ significantly from the mean for the UK.

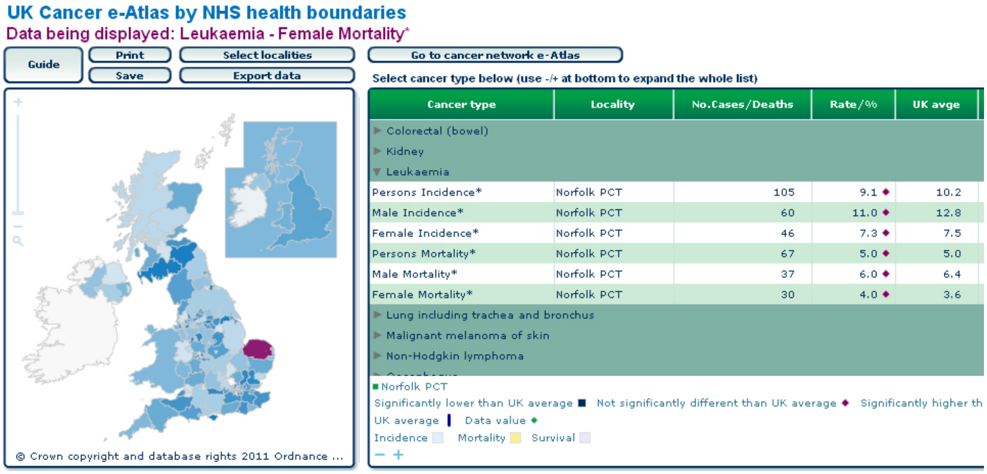


Figure 3.25: Statistical contextualisation
Source: UK cancer e-Atlas

Selection for assessments purposes: statistical calculations and summaries

In addition to statistical graphic windows, applications can show evaluations of the selection: for a simple selection, the profile of the entity will generally be clearly identified on the graphic. This is the case for Istanbul, where the profile is represented by the green trajectory in the parallel coordinates plot (PCP graphic) in Figure 3.26. In the case of multiple selection, statistics will be shown (for instance the mean for numerical variables and frequency table for categories) and related to the values for the space under study.

Figure 3.26: Global statistical description of area (left) and description of the selection (right)
Source: Cartovista - http://www.cartovista.com/see.aspx

From these evaluations, the user can generate questions and work by trial and error, while at the same time mobilising his or her abilities for assessing similarity and difference between values. As shown in Figure 3.26, the profile of crimes recorded in a zone of 2km around the Etobicoke-Lakeshore police station is very different from that for Toronto. As the graphic representations are suited to the selection, it is possible to identify, for instance, an over-representation of crimes such as "theft" and "drugs" in relation to "assault" and "robbery", and thus to analyse differences in distribution in the course of the day. These are all elements which one after the other enable differentiations to be evaluated locally.

According to need, the applications will deploy the most suitable functions to cast light on the positioning of an entity. There are several ways of performing a selection on the map, each being determining with respect to the way in which the space can be "read". A rectangular selection tool introduces solely the logic of proximity. A circular selection tool can be linked to a gradient reading model for a periphery in relation to the centre. We also find, as in figure 3.27, selections based on contiguousness, i.e. the selection of "neighbouring" elements. In this example the figure represents the range of values associated with the selection, and the pink curve corresponds to the country in the centre of the selection. It can be seen here that in 2013 the birth rate in Egypt is positioned centrally in relation to the range of neighbouring values.

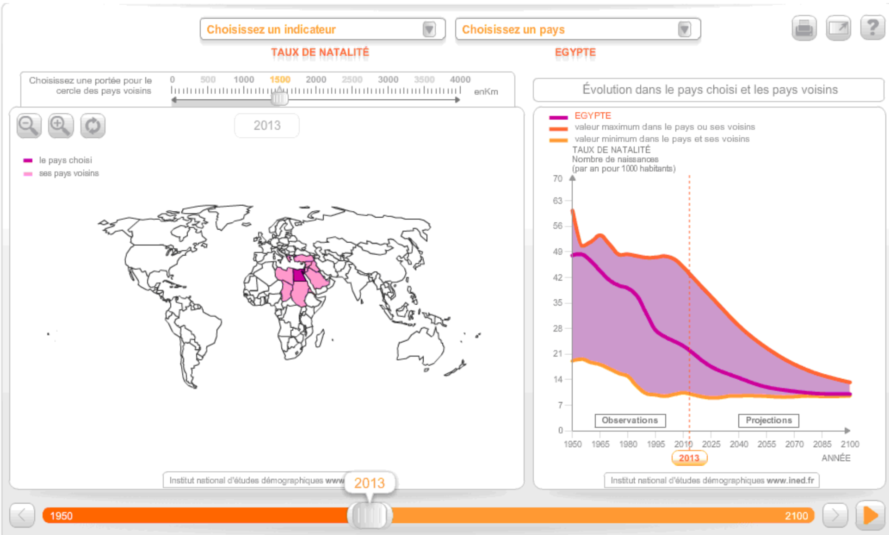


Figure 3.27: Global statistical description of area (left) and description of the selection
Source: World Atlas of population, National http://www.ined.fr/fr/tout_savoir_population/atlas_population/

Finally, in certain systems it is possible to follow a logic related to administrative subdivisions, where an administrative unit serves as the selection filter, as in Figure 3.28.

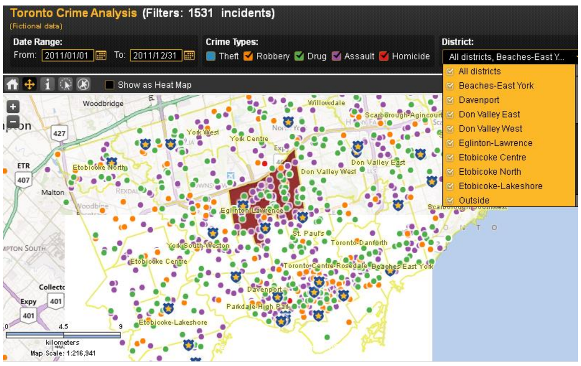


Figure 3.28: Selection of entities included in an administrative zone
Source: Cartovista - http://www.cartovista.com/see.aspx

Comparing levels

Most systems integrate this fundamental characteristic of multiscalar observation of territories. This can be done in several ways:

- selecting entities of a lower order: select "all regions in Sweden" (see paragraph above)

- cartographic representation: for instance, choose to represent the proportion of young people on levels NUTS 2 or NUTS 3 (OECD Explorer). This is connected with the MAUP. A powerful example allowing comparison of spatial organisation according to different level and type of zoning is the AIRE application (figure 3.29). It declines different representations for a given indicator based on administrative zonings (NUTS) as well as on grid. It is possible to change of level (administrative) or resolution (grids) in order to compare the differences of geographical level and of zoning.

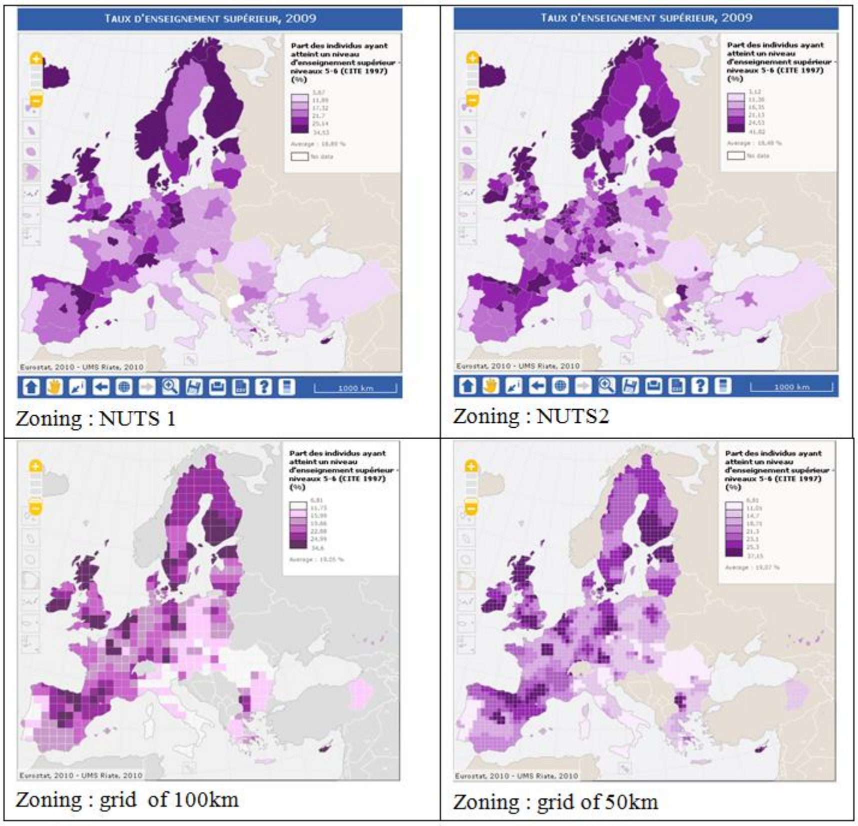


Figure 3.29: Several representations for one index, according to the type of zoning and its resolution. The % of high level of educated inhabitants in 2009 is seen through two different administrative zoning resolutions (first line) or two grid resolutions (second line).
Source: AIRE - http://aire.ums-riate.fr

- exploration and analysis: this is offered for instance in the HyperAtlas application, where it is possible to address the question of the relative position of the unit "Torino" (NUTS3) in relation to its neighbours, in relation to the higher administrative entity (NUTS2) "Piemont", and in relation to Italy. This tool offers several viewpoints on a piece of data according to this multiscalar logic (figure 3.30).

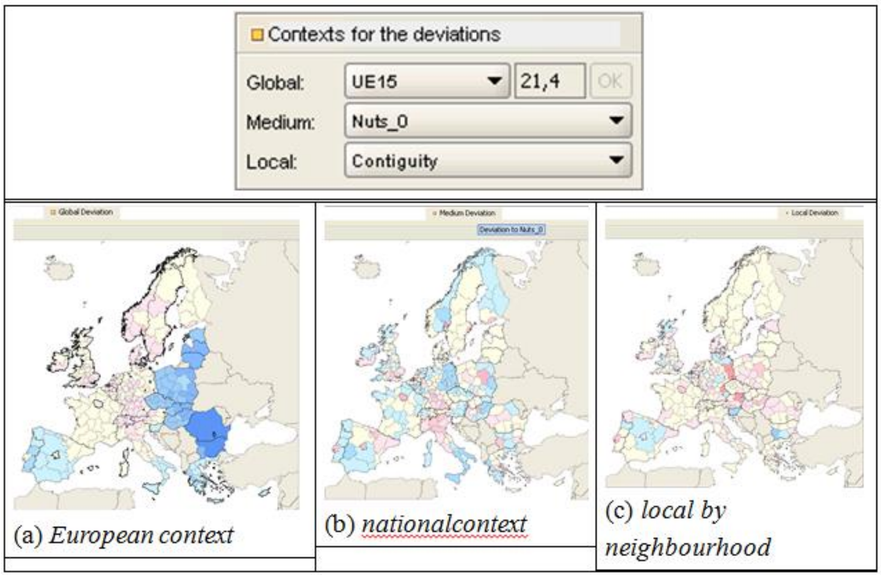


Figure 3.30: One index, three spatial organisation according to three different contextualization
Source: HyperAtlas - http://hypercarte.imag.fr/realisations.hyperatlas.html#download

Conclusion

We tried here, no to cover the diversity of applications, but to cover the diversity of functionalities and uses that these new cartographic atlases and applications offer. These environments make possible a very wide of cartographic representations of phenomena. At this stage one dimension which is crucial to understand the spatial process is missing: the time. The next part will present how such applications integrate the temporal dimension or how some of them are totally dedicated to spatio-temporal explorations.

4. Cartographic representations of spatial dynamics

What dynamics and what temporalities?

The study of spatial dynamics involves the study of transformations, changes and evolutions over time in spatial phenomena and their organisation. The main subjects of study in spatial dynamics are evolutionary processes, diffusion processes, mobility and displacement. Spatial dynamics can be studied over long time spans (several years, or a historical period) or over a short lapse of time (one the scale of a day or a month). When implementing spatial dynamics choices must be made about the formalisation of time (continuous or discrete) and about its levels of granularity. In addition, there are different way to apprehend the time to study the spatial dynamic:

- linear time, which corresponds to the position of a geographical object or phenomenon in time. It is represented by the calendar, and implies the notions of past, present and future

- cyclic time, which corresponds to geographical objects or phenomenon or that return at more or less regular intervals, in cycles.

Dynamic maps and the representation of spatial dynamics

Spatial dynamics may be represented in different ways:

- Static maps using adapted graphic semiology or representing indicator measuring the change such as variation rate.

- The collection of maps that allow the decomposition of the time : each map is associated to an instant T.

This is the case of the application MOVISS (Davoine & al): the application displays the variations of an indicator of social vulnerability according to the evolution of socio-demographic characteristics at the level of the neighbourhood over periods of the day. Each view corresponds to one period (morning, afternoon and evening). The choropleth maps show the spatial distribution of the index for each neighbourhood. The synchronisation between the views allow a comparative reading (figure 3.21).

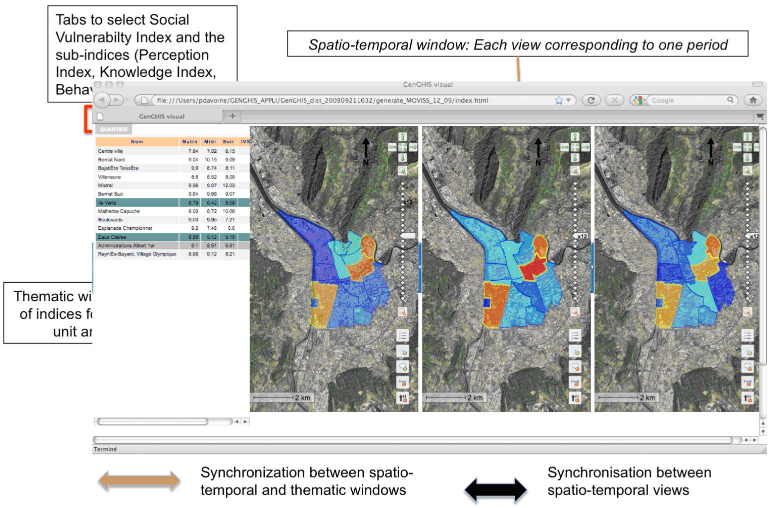


Figure 3.21: Dynamic view through a collection of static maps
Source: Davoine & al., 2011

- the animated maps that are also the dynamic maps , where interactivity is also really to manage the time. According to Antoni et al (2004) "animation is one of the most recent solutions developed to represent movements, changes or transformations of space in the course of time. Animation consists in displaying in rapid succession a series of maps representing the phenomenon of interest at different moments, thus giving the illusion of movement, displacement or change" (Cauvin, 2008), and creating the impression of a dynamic of space. (Kraak et al 2003) also underlined the fact that "animations are very useful for clarifying trends and processes, both in the explanation and the representation of spatial relationships". The animated map has several virtues: it enables spatio-temporal phenomena and changes therein to be demonstrated (Cheylan, 2007). It can also reduce graphic crowding effects. However to detect, analyse and understand trends, the user needs to interact with the animation. He or she needs to be able to conduct spatial and temporal reasoning simultaneously, and to do this needs to be able to visualise and interpret the temporal sequence and the pace of the animation also simultaneously. But animation can be difficult to "read", in particular on account of the speed of display, the time allowed to read, and difficulties perceiving graphic objects and their semantics. In addition, what occurs between each intermediate image is also important; sometimes even more so than what is represented in the images [Peterson, 1995]. It is therefore essential to combine animation with interactivity, providing for tools to interpret and control the animation, and also to manage its temporal extent and resolution.

Tools for managing animation

The aim is to navigate within the progression of the animation itself. This takes the form of a scrollbar that provides the basic functions (figure 3.22): starting up the animation, fast forward, fast backward, pause, and an indication time elapsed. This device first of all enables the animation to be replayed as often as the user wishes, enables pause on an image at a moment chosen by the user, or fast forward to a chosen moment. It can also include complementary function buttons, depending on the required level of interactivity, for instance the choice of speed of advance.

Figure 3.22: an example of time manager

Time management tools or temporal legend

These tools amount to temporal legends. They enable identification on the map of elements that are linked to the temporal dimension. The link between the map and the temporal legend is based on synchronisation: as the passage of time is displayed in the temporal legend, the corresponding geographical objects appear or disappear on the map, change colour or change their symbols, or are highlighted. The temporal legend also provides selection or temporal filter functions (selection of a date, of a period of time etc.), in particular when dealing with several levels of granularity.

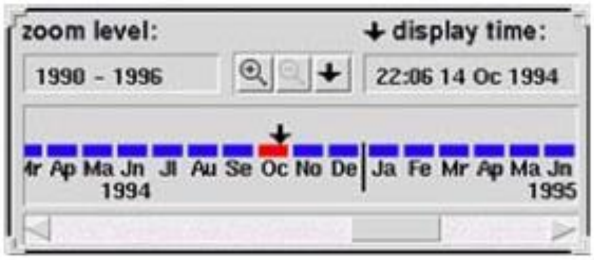
There are different types of temporal legend: they can be numerical (date or numerical time), graphic (temporal graphic or scrollbar) or iconographic (clock, calendar).

- the *timeline* is a linear, ordered, representation of time. Dates are displayed in chronological order from left to right (figure 3.23)

- the *timewheel* is a more cyclic representation of time, and is used to represent periodic, cyclic or seasonal phenomena. (figure 3.23)

- the temporal histogram shows the distribution of events over time or the trajectory of evolution of variables.

The time wheel is useful when exploring spatio-temporal data of known or anticipated cyclic nature. The user can specify the period of the cycle to be represented, and choose to view only those dates that correspond to a particular duration within the cycle. For example, we can suppose that the user is interested in rainfall variations in the Monsoon season over several years, in which case he/she would customise the time wheel to a yearly period, and then select the days, weeks or months of interest to restrict the investigation.



Timeline (Edsall & al 1996,, 1997)

Timewheel (Edsall & al Peuquet, 1996, 1997)

Figure 3.23: Examples of temporal legend

In certain cases, the temporal legend can have a sound track. This process is designed to draw the attention of the user by announcing dates or periods during scrolling.

Representing spatial dynamic

Applications may be distinguished according to the spatial dynamics they represent: some are dedicated to diffusion phenomena, other for spatial extension; still others are interested in the representation of the movements of individuals, or of the aggregation of these movements in the framework of study on the urban rythms…. We present here some examples of how these spatial dynamics may be illustrated in applications of dynamic cartography.

- TimeMap of World History presents the dynamics of the world settlement from 3500 BC to 2005 AD using interactivity. This is a long term dynamic and the chosen granularity corresponds to the periods that mark civilizations. There are simultaneously spatial process of appearance, disappearance and extension. The time illustrated by a time line where the different civilizations are represented with color (figure 3.24). Marks are irregularly spaced according to the duration of different civilizations .the association between color and time location help to read the map.

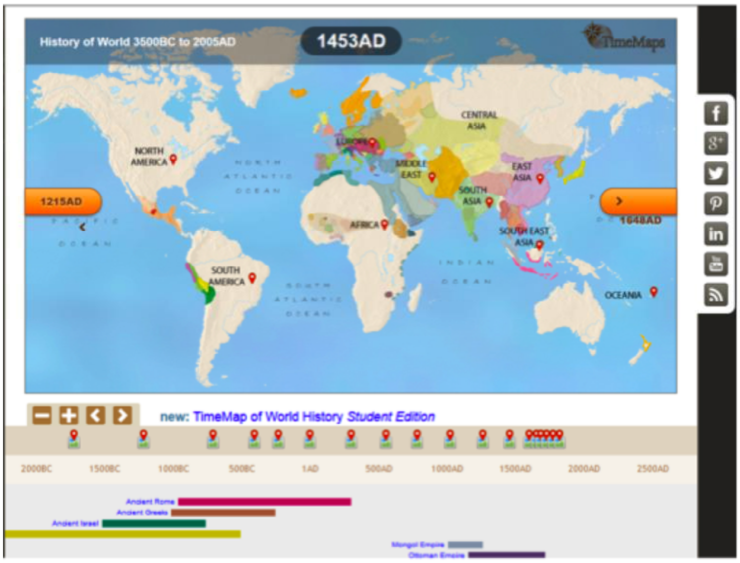


Figure 3.24: Animations of phenomena of diffusion
Source: http://www.timemaps.com/

Others examples show representations of statistical time series for the study of territorial dynamics. In this case this is no more the geometrical change that is represented (location, shape) but the evolution of the indicators: change is illustrated by variation on visual variables such as: color, size of circles…

This is the case in the application GapMinder (figure 3.25) that displays the population evolution of the countries in the world. As in the previous example, the legend for the time is a timeline associated to a display of the current date in order to support the view of the user. As to the time scrolls, circles' sizes evolve according to population size of the countries. Thus the user can evaluate the spatial differentiation of the evolution. He or she can stop the animation at any time.

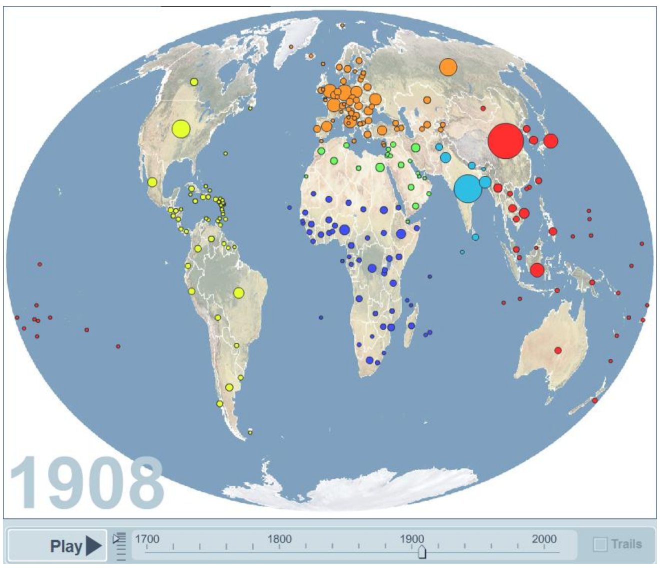
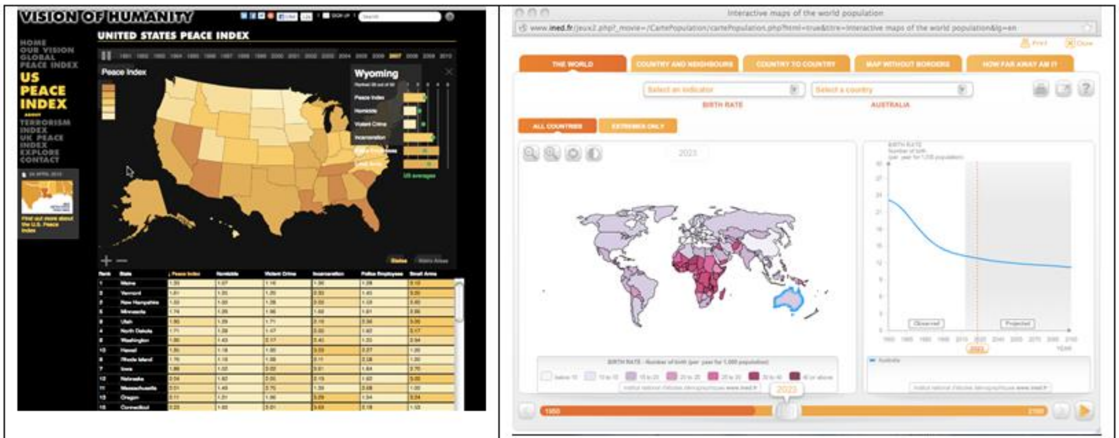


Figure 3.25: Evolution of the population of the countries
Source: GapMinder World - http://www.gapminder.org/world/

Exploration of the change in thematic data

The level of interaction define the degree of freedom the user has to explore the dynamics; As it has been previously presented some applications integrate functionalities for exploration. In the field of representation of spatial dynamics, the applications may also associate different synchronized views: temporal graphics , time series data, maps. In this case the animation concerns all the views as well as interactivity with timeline.

This is the case in the application "Global Peace Planet" (figure 3.26a): the three components of the interface are synchronized: map, table and contextual graphical view located on the top right corner. Map is synchronised with the cursor scrolling on timeline, and colours of the units change with evolution of values, as well as graphic displaying global statistics for the main indicators. This is also the case for the world demography atlas (figure 3.26b): the time scrolling affects all the views, here the map and the represented trajectories.



(a) Global Peace Planet
www.visionofhumanity.org/gpi-data/

(b) World demographic atlas
www.ined.fr/fr/tout_savoir_population/atlas_population

Figure 3.26: Animation and multi view environment

Some applications offer a possibility of multilevel exploration of the dynamics. This is the case of the application "harmonie-cites" (figure 3.27) where it is possible to represent as well the evolution of the urban system of the USA, as the extension of one given city from 1800. This allows visualise phenomenon such as diffusion and pioneering front as the urban system developed in the USA, as well as the extensions of given cities and their population trajectory in comparison the one of the whole urban system. This last view allows to approach the differences of rhythms in the evolution. From the semiological point of view, animation offers new perspectives: here transparency is used to display the memory of the different steps of the extension of the delineation of the cities.

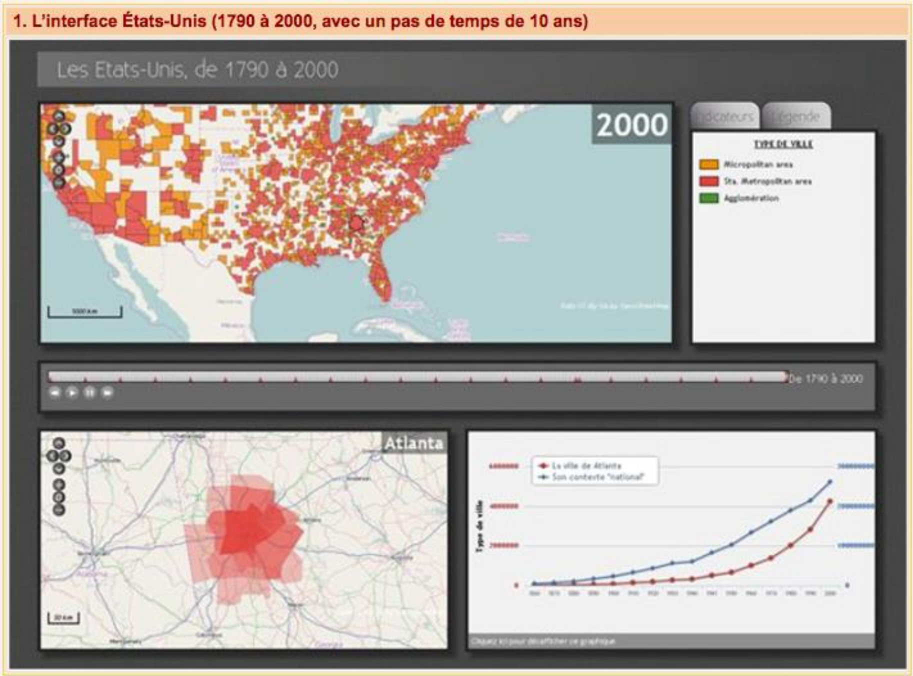


Figure 3.27: Animation and multi-level exploration
Source: http://mappemonde.mgm.fr/num27/fig10/fig10301.html

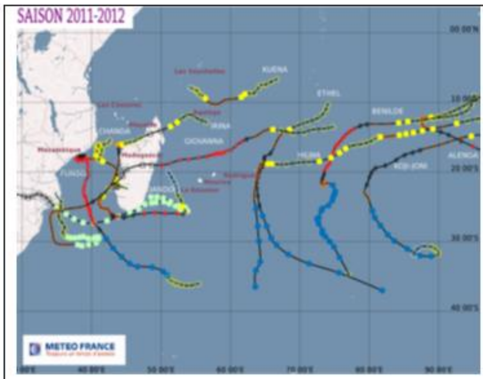
Animating the movements

Time is an intrinsic feature of mobility; thus the representations won when integrated in interactive and animated cartographic applications. Most of the application proposes the representation of the individual mobile trajectories. But when there are too many individuals such representations are no more efficient and it is necessary to aggregate them at any geographical level and to represent either the incoming and outgoing flows or there result, that is the "presence" on the zone, or the variation of the presence.

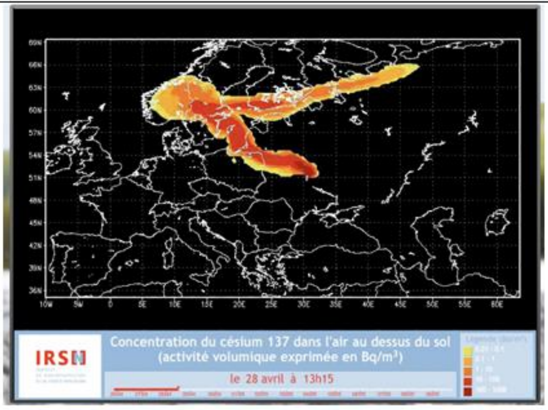
Mobile trajectories, such as cyclone or boats, or individuals, are represented through the display of a succession of points that are the different registered locations (figure 3.28a).

Some applications propose a representation integrating an information on the state of the object. For instance figure W8a, the cyclone changes of location, and its type changes also: it begin as a "depression", then becomes a "tropical depression" before it finishes as a "cyclone". This is also useful for the representation of the travel survey where there is a need of representing movement and transport mode as well as immobility and activity.

The example of the displacement of the radioactive cloud of Chernobyl is interesting because it represents simultaneously the trajectory of the cloud, the deformation of its shape and the involution of its physico-chemical characteristics (figure 3.28b).



(a) trajectories of cyclones during the period 2011-2012 www.meteo.fr/temps/domtom/La_Reunion/webcmrs9.0/francais/index.html)

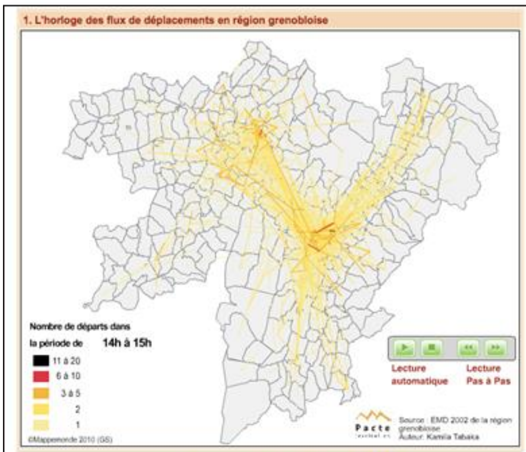


(b) Trajectory of the radioactive cloud of tchernobyl http://www.irsn.fr/FR/popup/Pages/tchernobyl_video_nuage.aspx

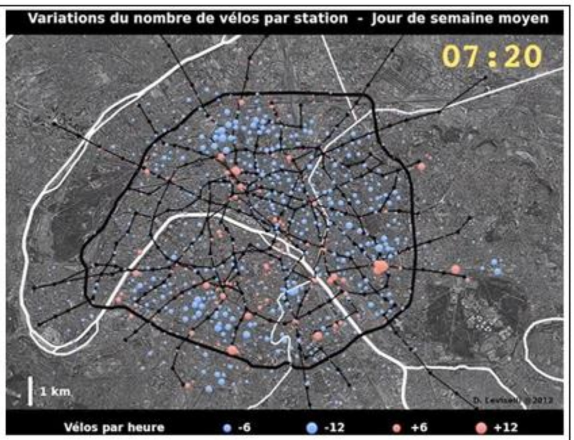
Figure 3.28 : visualisation of mobile trajectories

Some applications propose some representations of the movements at the level of the places. That may be the visualisation of the origin-destination matrix. This is often the case of the studies based on commuters. The figure 3.29a illustrates such representations: flows between places are represented by lines or arrows from origin to destination. The color of the line represents the intensity of the flow. As the time scrolls, flows change and the user discovers the film of the daily movements on the concerned territory and visualizes simultaneously the polarisations and the temporal rhythms of the connexions between residential places and employment centers.

Figure 3.29b illustrates another way to visualize urban rhythms. This is a synthetic view of ativity of the terminals of the sharing-bike system in Paris.



(a) Commuters in Grenoble
Source:http://tel.archives-ouvertes.fr/tel-00420343/fr/



(b) Activity of the terminals of bike-sharing in Paris.
Source : Leviselli, 2013

Figure 3.29: visualisation of movements aggregated at the level of the places

Some applications propose 3D animations in order to explore spatio temporal dynamics and urban rythms (Klein 2007; Antoni & al 2012). The figure 3.30, shows an example of animation based on the daily commutting of the population. The third dimension is used to represent the thematic variable to map. The temporal legend is a timewheel with two circles: one for the hours; an other one for the main displacement periods (rush period) (Antoni & al 2007).

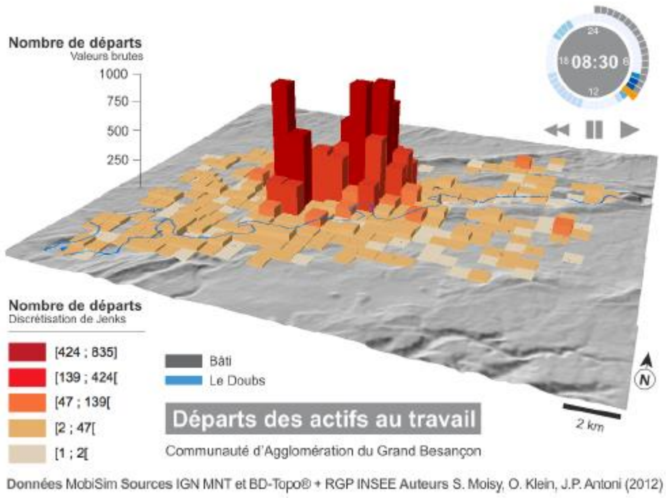


Figure 3.30: The city animated according commuters' movements
Source: Antoni & al 2012

With the growth of mobile individual data, these environments will become more and more useful. The studies on spatio-temporal data such as those used for the analysis of urban rythms have specific needs. Various examples are developped such as in Dykes and al. (2005), Andrienko (2006)., Klein (2007), and Cauvin & al (2008).

These types of animated cartographical applications may be considered as kind of exploration tools. Other applications based on the geovisualization or computanional visualization (Kraak & al 2010; Yuan & al 2008), are developped to represent spatial dynamics. They use the main exploration tools described in §3 , and are based on the multi-view, multi-representation, and contextualization principles. The figure 3.31 shows an example of these kind of tools: the animation is integrated in an exploratory environment: thus all the views are animated. The user can manage the animation speed, and follow the evolution of all the relations that are illustrated in the different views (maps; histograms, scatter graphs….)

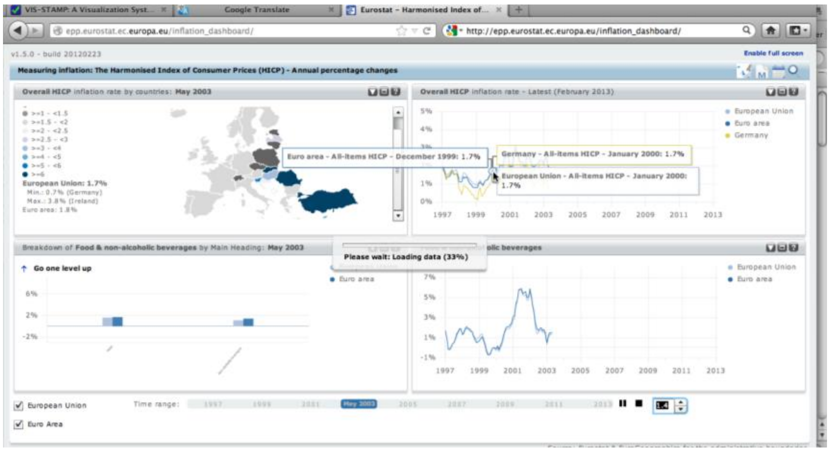


Figure 3.31: Exploration of the spatio-temporal data
Source: http://epp.eurostat.ec.europa.eu/inflation_dashboard/

In the same type of environment, Vis-stamp application (figure 3.32) is a geo-visual analytic software that couples computational visual and cartographic methods. It uses different type of grapics to represent spatio-temporal distribution: Self Organizing Maps (bottom right) and the associated matrix (top left); map collection (top right); The parallel coordinate plots graphic (bottom left), complete the temporal dimension (Yuan 2008).

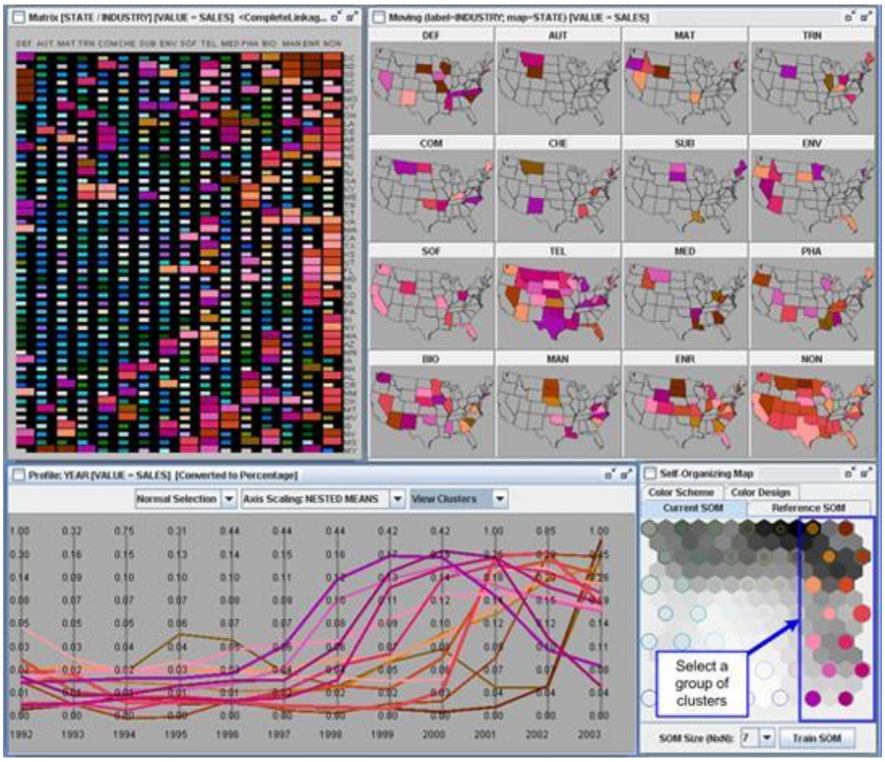


Figure 3.32: Vis –Stamp: A Visualization System for Space-Time and Multivariate Patterns
Source: http://www.spatialdatamining.org/software/visstamp

Conclusion

With the growth of data, more and more data will integrate the temporal dimension. Thus more and more applications will be developed for a better understanding of spatial dynamics. These applications are based on the use of the animation associated with the interactivity. This approach provides new opportunities, but also, complicates the development of these applications. These applications require specific computer developments (Java, Flash …) and the production of dynamic maps should develop also the use of dynamic visual variables, appropriate to a better visualization and comprehension of spatio-temporal information. This is already known. DiBiase and MacEachren (1992) describe six dynamic variables which must be use into dynamic maps: duration, order, rate of change, frequency, and display time and synchronization moment. The challenge is now that they are well used in these spatio-temporal applications because they influence the efficiency of dynamic maps.

5. Original cartographic representations

Regarding cartographic representations *per se*, most applications produce very classic maps of territory. In this respect we are in line with the observations in Task 2.

Most of the online atlases (Figure 3.33a) propose classic maps, such as choropleth maps, inventory maps (points) and proportional circle maps. Very few applications offer other base maps than the basic grid used – topographical base maps for instance are rarely used. When they are, it is generally only in the forms of a superimposition of raster images or vectorised layers, and interactivity enables a switch from the map to the image via a transparency system (Figure 3.33.b).

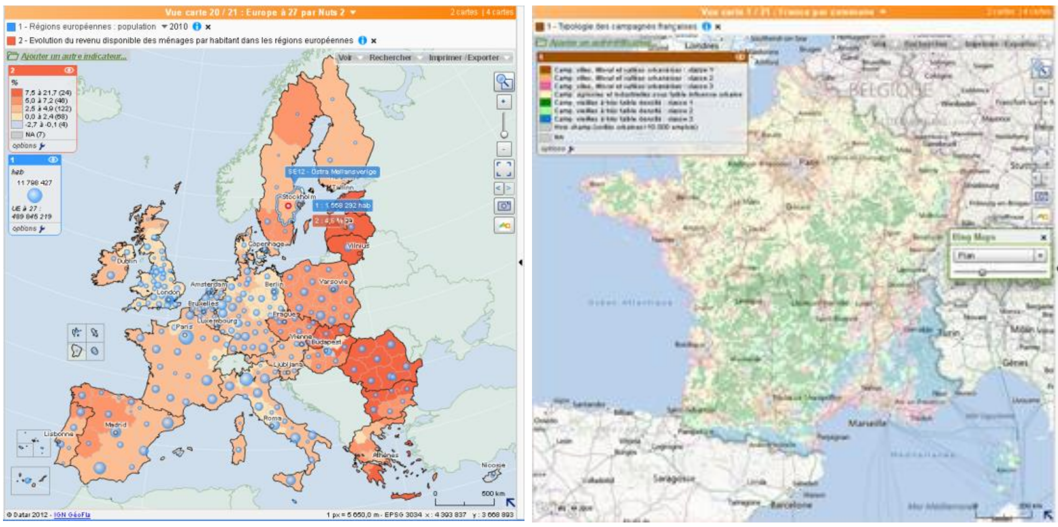


Figure 3.33: (a) classical choropleth cartographic representations and (b) representation mixing choropleth map and topographic map by transparency.
Source: DATAR - http://carto.observatoire-des-territoires.gouv.fr

We did however identify a few more original cartographic productions, based on operations of "re-expression" (Kraak 1998), such as cartograms, continuous surfaces, and 3D cartography. Even if these techniques innovate, they are not new. They have however spread with the arrival of new technologies, and find their place in interactivity and animation. We now propose a few commented examples of this type of production.

5.1 Cartograms

Cartograms are among the most original cartographic productions. Representations in the form of cartograms (or cartograms) yield cartographic representations in which space is intentionally warped on the basis of a criterion that is more functional than geometric, for the purpose of conveying a message. The space is not Euclidian; it is a space that is relative to a phenomenon that one wishes to represent. There are several types of cartograms: generally "surface" cartograms and cartograms which focus on surface areas (where for instance the surface area of a country is proportional to its wealth), are contrasted with "distance" cartograms, which focus on distances between places (for instance their accessibility). These representations have been used for some time (Figure 3.34), and several methods can be used for their implementation. They are nevertheless rather complex to manage, and until recent years only a few specialised centres had developed programmes enabling their production.

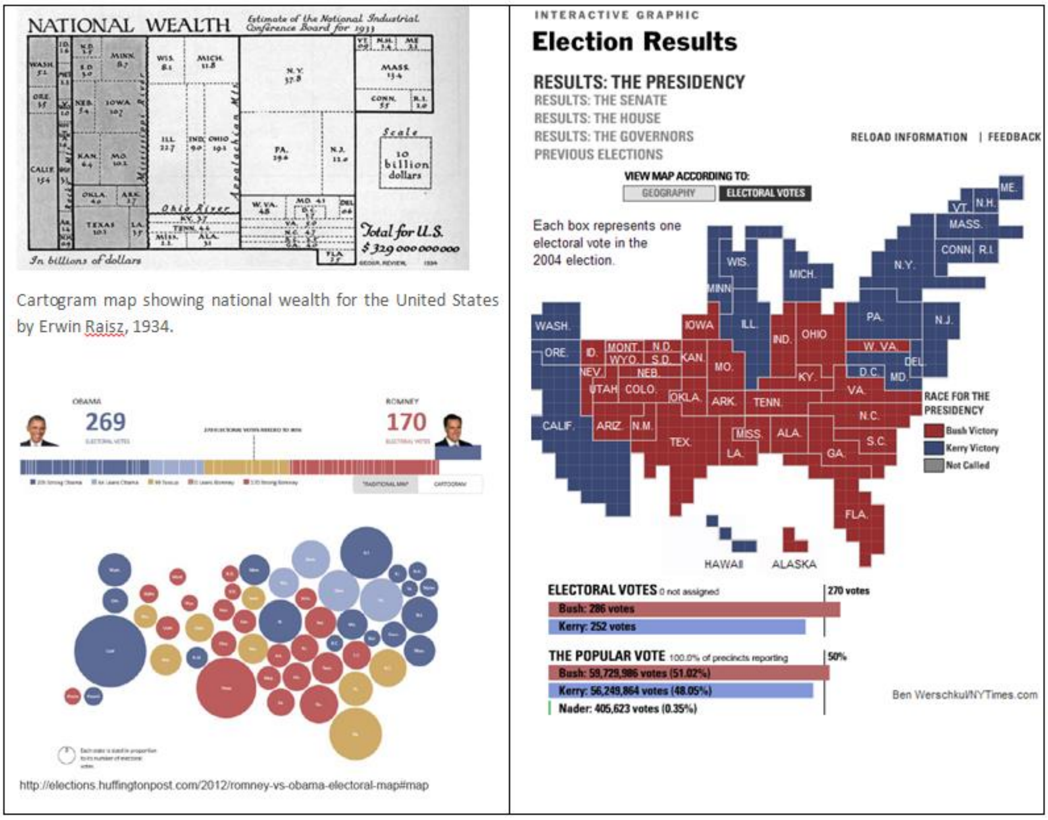


Figure 3.34: Cartograms
Source: http://www.gislounge.com/area-cartograms-explored/

Today this type of representation is disseminating by way of specific programmes integrated into widely accessible software. Even so, these maps are not easy to read, since they completely distort the known contours, although in most cases the topology (patterns of contiguity among entities) is preserved. They therefore require the user to be well acquainted with the space in question, and cannot involve too many entities. In particular, it is a good thing to integrate them into applications enabling visualisation and interpretation by comparison with the better-known Euclidian representations.

Among the different experimentations of recent years, we can cite the Worldmapper project (www.worldmapper.org) which contributed to the UN millennium project for development by publishing cartograms for numerous indicators on world scale (Figure 3.35). These maps are not animated, but to facilitate their reading the authors choose to use colours to map the geographical proximity of the countries, thus displaying large regions. In all cases, the reading of this type of maps operates with reference to known surface area relationships, and the difficulties remain.

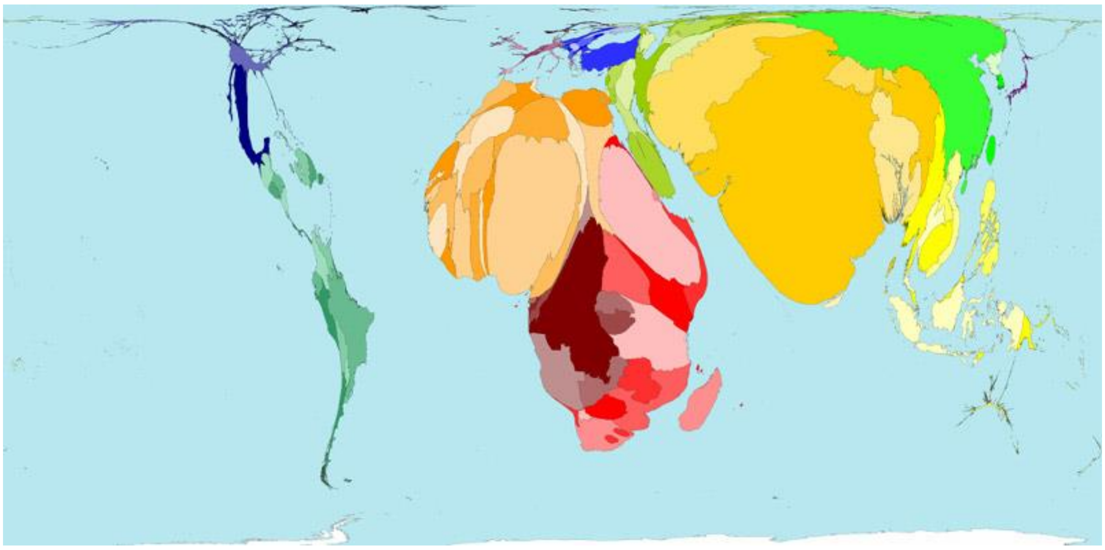


Figure 3.35: Example of cartogram

Source: A.Badford - http://mappemonde.mgm.fr/num17/articles/art08105.html

Infant mortality. The surface area of the different countries is proportional to the number of children under one year of age who died in 2002. Data UNPD 2004, World Report on Human Development, table 9

Examples where animation markedly improves comprehension of the distortion are those than enable the shift from cartograms to a representation in Euclidian space (figure 3.36). Seeing a territory "'crumple up" gives a better understanding of the trend of the distortion, the places that become "closer" and more central and those that become more distant because of their poorer accessibility.

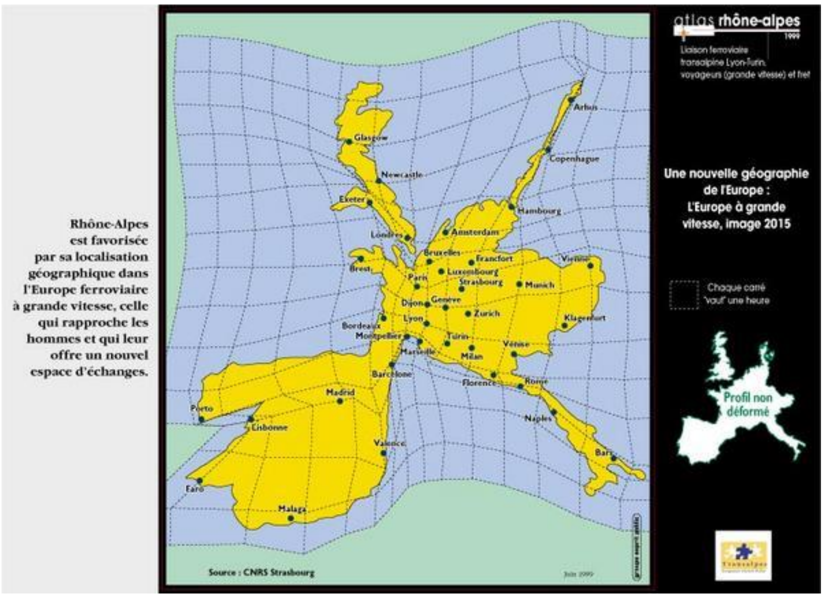


Figure 3.36: Reading cartograms by comparison with referential map
Source: Atlas Rhône-Alpes, CNRS Strasbourg, juin 1999

To represent accessibility, there are also applications that use other graphic devices than the map to represent differences in space. This is for instance the case with "commuting scales", which aim to analyse the travel times between different places of residence and workplace (Ecole Polytechnique Fédérale – EPFL, figure 3.37). Two parallel views of the localisations are used: a classic view of Euclidian space (in the form of a map) and a space-time view in the form of a graphic in which the north-south-east-west orientations of the locations in relation to EPFL, positioned in the centre of the illustration, are retained, but where the distance from the centre corresponds to the time taken to travel the distance between place of residence and workplace.

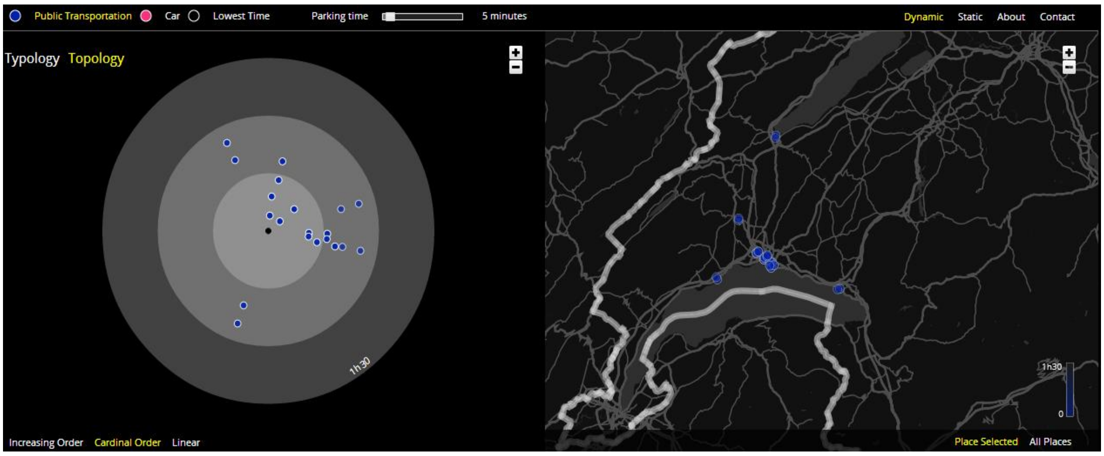
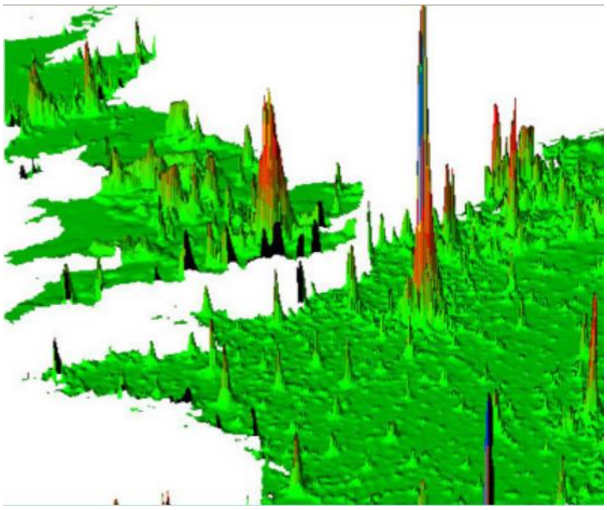


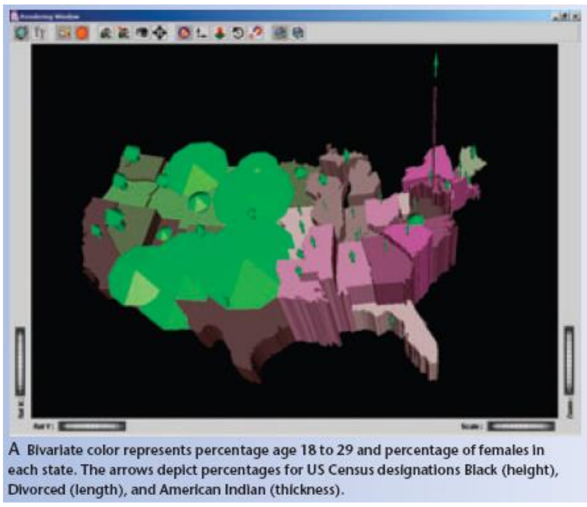
Figure 3.37: Two representations of the localization according to the time accessibility (left)and according to the geographical location (right)
Source: Commuting Scales, Chôros Lab, http://choros.ch/cs/

5.2 *3D* Cartography

The third dimension also enables the development of original maps, putting objects "in relief". There is generally some redundancy in the representation: the mapped variable (colour) is also the variable relating to altitude (Z). Figure 3.38a shows a representation of densities in Europe on a continuous surface. Figure 3.38b shows a 3D map for the data using territorial zoning. When the surface is not continuous, these maps can also be referred to as prism maps.



Source : Source /mappemonde.mgm.fr/num14/articles/art07202.html (n°86 - 2007)



Source : Geovista- http://www.geovista.psu.edu/software/

Figure 3.38: continuous 3D map - prism map

These representations, like cartograms, gain from environments that enable the user to interact with the perspective provided. Depending on the spatial organisation of the phenomenon studied, the user may need to be able to explore relief or change the viewpoint, since certain high points can conceal lower areas.

Other ways of using 3D have been explored. For instance Figure 3.39 shows how 3D is used to trace time-distances. The network linking the summits is the fastest and serves as the reference. The other networks, not so rapid, are represented on slopes to express a longer time-distance.

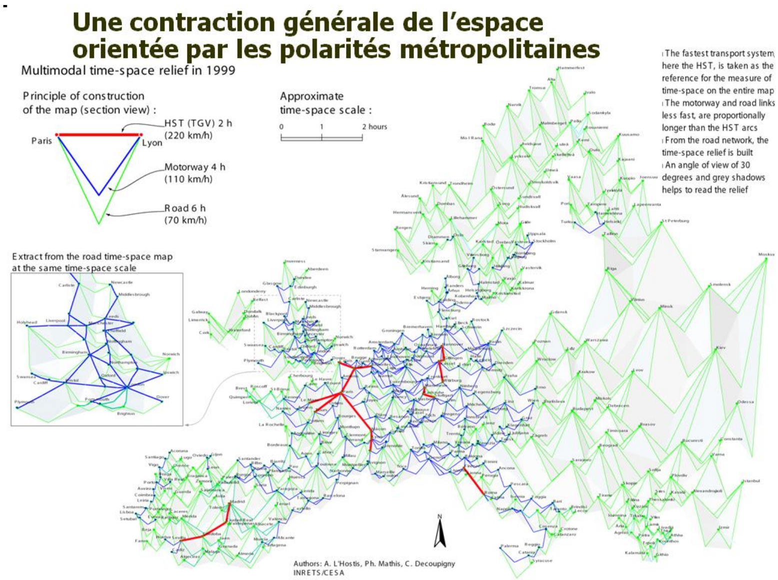
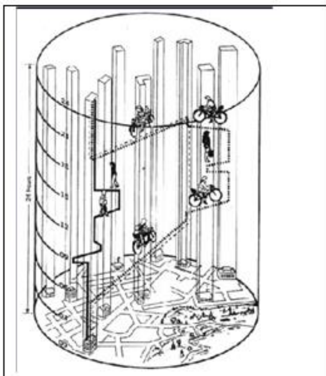
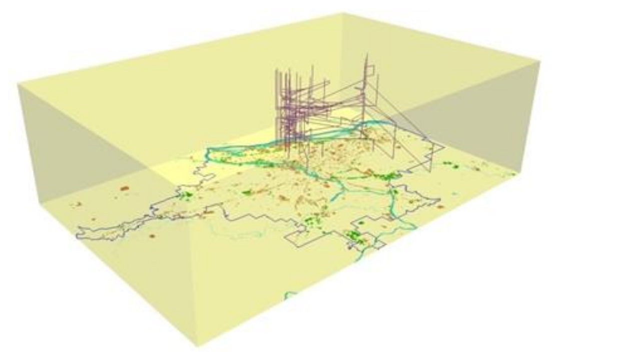


Figure 3.39:"A general contraction of the space oriented by metropolitan polarization": an original use of 3D to express the differential of speed over roads.
Source: Lhostis 1997

A last example of the use of 3D is that of the cartographic representation of individual mobility patterns, which is allied to Hagerstrand's Time-Geography approach. Movements are represented across the territory, and the third dimension is used to represent time. Individual space-time paths may be read in the cube as a series of movement and stops. Travel times and times of immobility are read together (figure 3.40)



Space time path (Hägerstrand 1970)



This figure shows the space-time paths of the African-American women in the Portland Activity-Travel Survey (Oregon, 1994-95) dataset. It shows that the activity spaces of these women are more restricted than individuals of other gender/ethnic groups in the sample.

© Mei Po Kwan

Figure 3.40: Space time paths according to Hagerstrand point of view (left) and implemented in a GIS by M.P.Kwan (right)

5.3 Smoothing and interpolation

Smoothed maps (i.e. maps showing continuous surface areas) are increasingly widely used. They are not newcomers either, and have always been used in environmental sciences to represent continuous phenomena from sample data. They are now frequently used to represent human phenomena for several reasons:

- technical reasons: all GIS have integrated interpolation procedures enabling a shift from data measured on grids or points to a continuous surface representation.

- methodological reasons:

• methods have been developed for the purpose of offering the most appropriate functions, for instance for social phenomena

• the continuous surface is a common reference that enables observed data to be confronted with different references (different sources, or change in grid between dates).

One example is that presented in the AIRE environment (Figure 3.41). Here the originality is that the representations were developed using a smoothing function based on a method of potential. This method, which is specific to phenomena that are non-continuous in space, as is the case with social phenomena, is not integrated into the classic software of the GIS type, which proposes interpolations on classic samples (kriging, mathematical functions etc.).

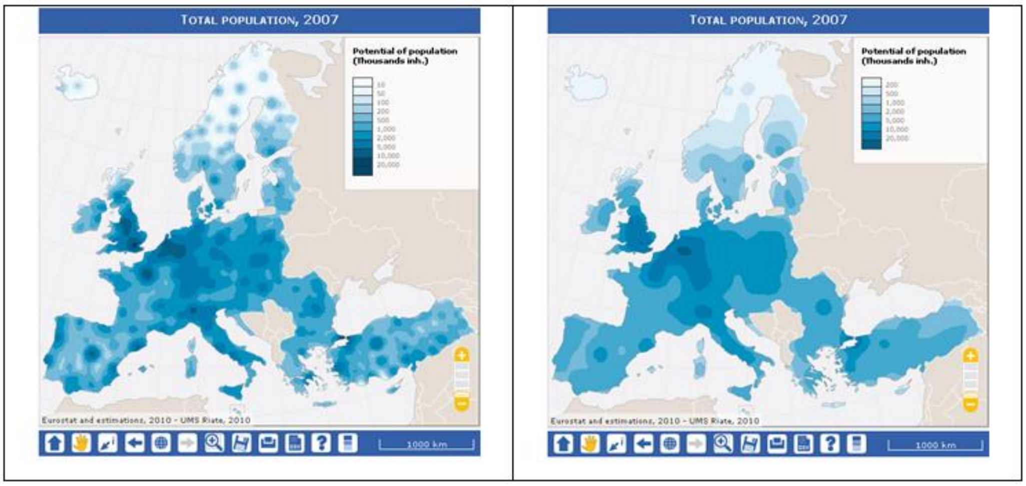


Figure 3.41: Two surfaces representations based on potential smoothing functions according to two different range: 50km (left) and 100 km(right).
Source: AIRE- http://aire.ums-riate.fr

This type of map is extremely effective if the aim is to identify a trend in the general spatial pattern. However it is at the cost of the link with values at local level, and of the accurate delineation of entities on which the phenomenon was measured. Thus this type of representation is advisable either when the purpose is to highlight a trend in spatial organisation, or when it is to publish results with a degree of confidentiality. They are however generally not well received by users who generally wish to accurately identify the value of a given entity. Here again interactivity can be a means to enable the shift between two types of representation, each casting a different light (Figure 3.42).

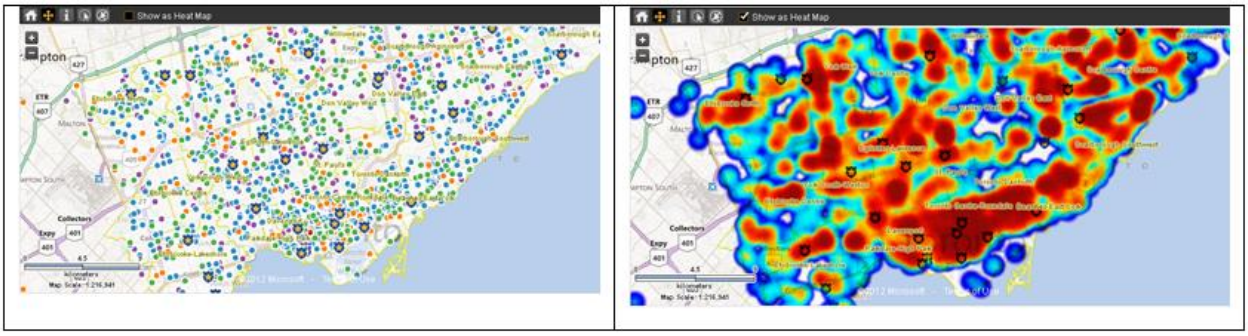


Figure 3.42: Switching between two types of representation: from distribution of points to density surface (heat map).

Source: Cartovista - http://www.cartovista.com/see.aspx

Smoothed maps are particularly suited to the use of 3D (Figure 3.43). As already mentioned, maps in this instance will present a degree of redundancy, since colour and height are associated with the same variable.

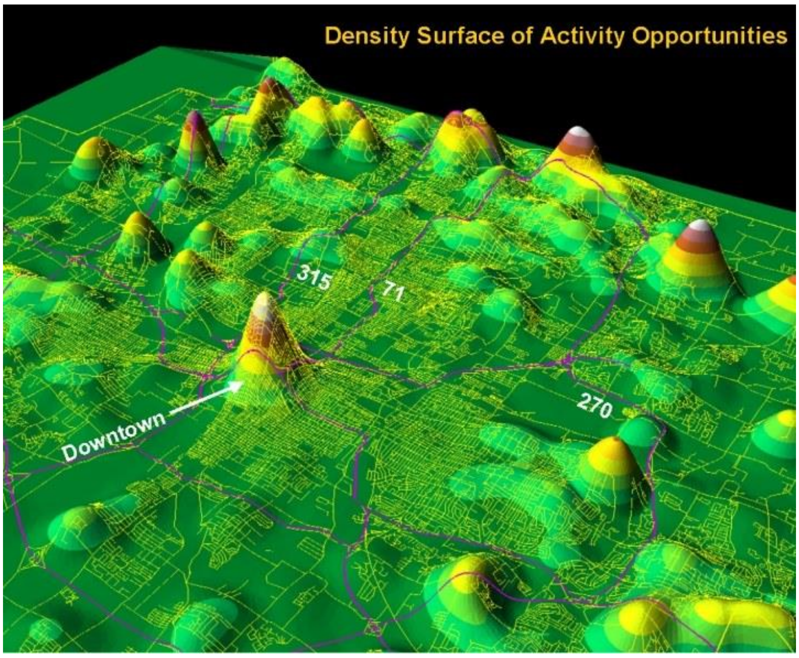


Figure 3.43: Smooth and 3D

Weighted area of 10,727 commercial parcels in Columbus, Ohio, was used to generate this opportunity density surface.

Source: © Mei Po Kwan (http://www.meipokwan.org/Gallery/Density.htm)

5.4 Moving representations

The production of all the cartographic developments presented above requires highly technical environments. This does not prevent other parallel developments. Here we are looking at fairly isolated experiments, but which are easily reproducible: this is the case for figure 3.44, which shows a representation habitually used to show physical phenomena continuous in the space .These representations initiated by Tobler (1987) are used either to represent the result of movements, or as in the case here to represent a change. Here we have the gains and losses of the Republican Party between the elections of 2004 and 2012. To represent change, the author uses a dynamic symbol that is classically restricted to flows. The orientation is used to emphasise colour – to the left, and blue, when the gains are for the Democrats, to the right and red when the gain is for the Republicans. The length of the arrows is proportional to the intensity of the gains measured in percentages. This type of representation is a form of semiological re-expression.

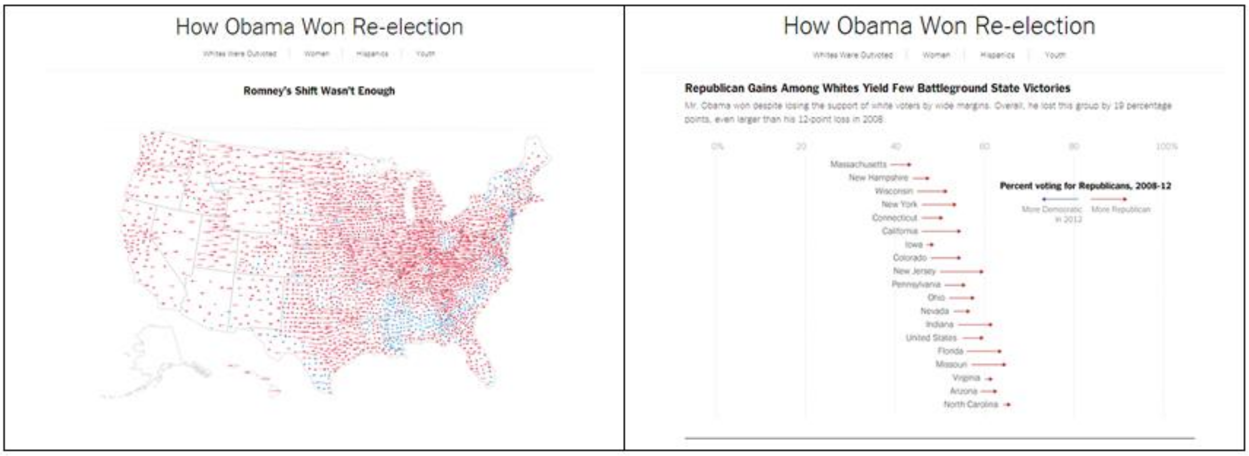


Figure 3.44: expression of movement for the cartography of change

Source: www.nytimes.com/interactive/2012/11/07/us/politics/obamas-diverse-base-of-support.html

These cartographic representations based on re-expression or "re-wording" of space are useful because they provide complementary viewpoints. It is therefore by comparison, using interactivity and animation tools, that these representations are the easiest to read. For instance Figure 3.45 shows four different images of the same phenomenon: mobility patterns in a city centre. Figure a- shows the phenomenon as it was recorded, in its complexity. Figure b gives precedence to a static view of "presences" in the territory, with a continuous surface of densities. Figures c and d provide dynamic views of movements, using the metaphor of "forces" operating in the territory. One uses the patterns resulting from movements at given points, and the other uses interpolation on a fine grid. Most of the original representations are implementations of techniques that have been around for some time (cartograms, 3D, spatial interpolation) but re-used in different settings, thus stimulating reflection.

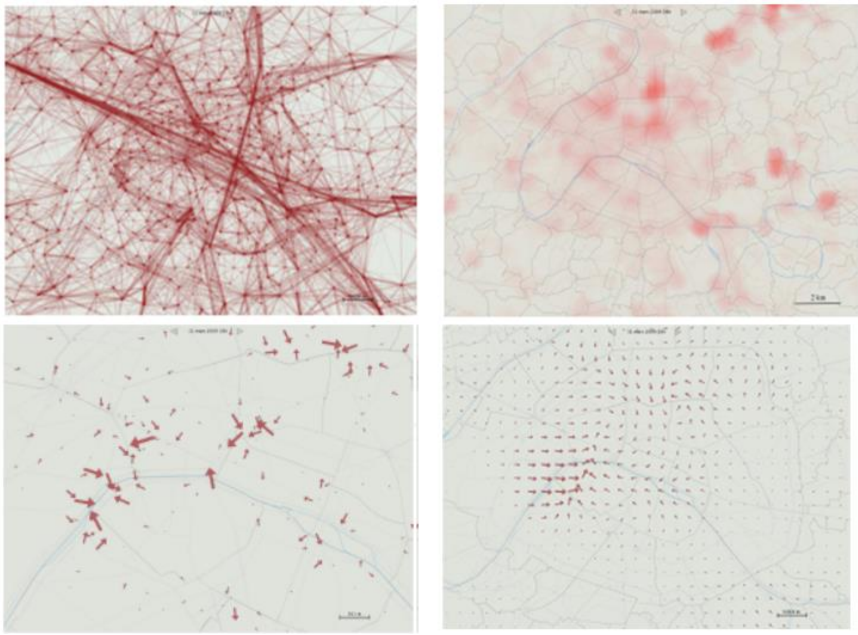


Figure 3.45: Four cartographical representations each casting different highlights of a single phenomenon
Source: Fen Chong, 2012

6. The main types of environment and some technical aspects

This part deals with the main technologic solutions allowing developing innovative applications of cartography. Some are produced thanks to open-source or commercial softwares, whereas others result from specific informatic developments, on the base of software components. Nevertheless, whatever approach is used for the development, two groups can be distinguished among the cartographic softwares, based on their functioning: web applications and desktop applications.

-Web applications are accessible through a web browser and so, can be used from any place and with several types of platform: computer, tablet computer, smartphone, etc. Thanks to this disponibility, their aims are mostly to communicate data to a large and possibly non-expert audience.

-Desktop applications can only be installed on one computer, what make them harder to share out, and are mostly dependent on the operating system. But they often have a greater power of calculation and more numerous functionalities than web applications. In fact, they target a different audience: they are addressed to an informed audience who want to make complex analyses on their data.

Web cartographic and technologic components

Most of the web applications are built from preconceived libraries of functions, called API (Application Programming Interface). Many web mapping services propose their own API to developpers, for example Google, Yahoo, ViaMichelin or the IGN's Géoportail. These editors'API have their own conditions of use and different kind of licence (free or commercial).

Openlayers API is different from the above-listed API because of its two-clause free licence and the large community of users who build it. It is as rich in functionnalities as others API but less “turnkey” for developpers.

On the technologic side, two main programming languages are used in these API: Javascript and Flash. They have both advantages and drawbacks, so much so that the editors often make two versions of their API corresponding to these two languages. They are equal in terms of functionalities and interactivity. Their difference is their visual rendering in maps. Using Flash produce smoother visualisations and is very advised to make complex animations on the map, even if Javascript allow too simples animations. The main drawbacks of Flash are that the user is forced to install a plugin in his web browser in ordre to view the animations, and that it is heavier to be read by the browser than Javascript, what could lead to slow down the application on the computers having low performances.

Other programming languages exist in cartographic API, but are more specific to some editors, such as Flex (a kind of improved Flash), Silverlight, .NET, Java, etc.

« Turnkey » software solutions

The turnkey software solutions, also called turn-key, enable the user to develop their own applications. Two main categories may be distinguished:

-In desktop generic applications, the user can integrate his own datasets. He can use the large set of ready-to-use functionalities of analysis given by the application. This is the case of the applications HyperAtlas (analysis) or GeoDa (exploration). The GIS (Geographic Information Systems), which are the most powerfull and generic applications to visualize and analyse spatial data, also give the possibility for the user to develop his own analysis functions, such as in ArcGIS or QGIS where scripts in Python are usable.

-Some web applications propose GIS functionalities, such as advanced analysis or developing electronic atlases, thanks to API associated with a graphic user interface. They are then called web-GIS. Their posted aim is mostly to allow collaborative work between colleagues working in different places. For example, this is done by ArcGIS, Dynmap, CartoVista, CommonGIS or GeoViz Toolkit, GeoDa.

Typology of the environments according to the services offered

Generally speaking, computer environments for cartographic visualisation differ from the others in three aspects:

- their objectives: is the tool's purpose to present data in descriptive manner, does it provide simple analyses, or does it enable in-depth exploration of the information?

- how generic is the environment? Can the tool be applied to any data, or is it dedicated to a particular field of application?

- what is its audience? Is it a tool intended for use by professionals, with sound knowledge of the area of study, or by the general public?

On the basis of these three characteristics it is possible to classify the main types of environment for cartographic visualisation, as can be seen in the table below.

Objective	How generic?	Users	Category defined	Examples
Presentation	dedicated	specialist/non-specialist	Visualization tool for topographical infrastructures, or statistical and environment data	-World Atlas -IGN Portal -World Mapper
Analysis	dedicated	specialist/non-specialist	Dynamic cartographic application	-Statistical Atlas of Switzerland -World demography atlas
Analysis	generic	specialist	Generic environment for data analysis	-HyperAltas -GapMinder
Exploration	generic	specialist	Generic environment for data exploration	-Geovista -GeoDa -OCDE Explorer -Vis-Stamp

Table 3.1: Typology of cartographic environments

Innovative cartographic environments: the participative cartography

With the ever greater development of Web 2.0 and social networks, Internet users today want to be players in the applications that they use. The wealth of Web applications for cartographic visualisation thus also depends on the scope afforded to users for the use of functions and the part they can play in the design of the visual result. Thus numerous applications enable users to integrate their own data in the interface so as to visualise or even analyse that data. We already present some "stand-alone" applications. But online applications also enable the integration of a user's own data in the interface for the unique purpose of cartography. Then users can export the result (printout, numerical export in pdf, GPX or other format). This is the case with IGN's Geoportail, Google Earth, OpenStreetMap or the ArcGIS Online platform.

Some applications go even further, offering users the option to contribute to the content of the interface in durable manner by integrating data that other users will then be able to access. Thus the GoogleMaps application is linked to the Panoramio website (figure 3.46) where users can attach photographs taken across the world. The photographs can then be viewed on GoogleMaps. The contributions of users, which are extremely numerous, thus cover the whole globe. Alongside, OpenStreetMap goes as far as mobilising users to create the basic content of the application: the base map, which gathers all the elements in the landscape, from land use to details of infrastructures.

Figure 3.46: Participative cartography, the example of Panoramio
Source: (http://www.panoramio.com/)

CONCLUSIONS Task 3: For an Innovative cartographic language

Since twenty years, cartography cannot anymore be considered regardless of electronic environments. The cartographies are produced in numeric environments, such as e-atlases, dynamic cartography applications or geovisualisation applications. These applications use all the richness of informatics' tools, starting with interactivity and animation.

Here are summarized the different levels where the innovation in new technologic environments is now influencing the cartographic production:

- « new data », « new thematics »: the explosion of data involves new needs in terms of environments but also of cartographic representation. Data become more numerous in the map, what can lead to a cognitive overload: from that, it is difficult to select an only point of view without letting the user explores the data and makes its own choices. Data is also qualitatively more varied (individual data of trackage, from social networks) and need the experimentation of new environments.

- « new environments »: as described before, the map enters in environments with richer functionalities of exploration. Lots of national institutes have developed their own dynamic cartographical applications; additionally, this kind of applications is developed for more and more public institutions, whatever their field of competence (public health, teaching, demography, security, ...). New dynamic cartography applications ensure the transparency of public statistics and allow to stimulate the reflection of citizens (Apparicio, 2012)

- « new representations » et « new semiology »: On the side of cartographic representations, these production environments allow a wider spread of representations that are not any more new, such as smoothing, cartograms or 3D. Moreover, these cartographies are leveraging by their publication in environments using interactivity and animation, because they can be viewed differently than cartography of reference. Finally, the animation has opened a new semiological potential.

In conclusion:

- Web grows richer with the development of a multitude of interactive applications, but this high number does not pair with a high diversity of functionalities.

- Some of these cartographic environments belong to the category of very powerful exploratory analysis tools: they are located in the "exploration" side of the MacEachren's cube (figure 3.1, page 77). Nowadays, most of these applications pair with animated tutorials in order to allow a less specialized audience to understand the interest of these environments: the animation tells a "story" about the data with the functionalities of the application and the animation about the exploration is then located in the "presentation" side of the cube.

- Today, new perception questions are emerging: what is the real contribution to knowledge of these new kinds of cartography?

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Webography Task 3

Specific cartographic applications

Statistical Atlas of Eurostat	http://ec.europa.eu/eurostat/statistical-atlas/gis/viewer/
National Atlas of the United States	www.nationalatlas.gov
Atlas of the World	http://www.worldatlas.com
Statistical Atlas of Switzerland	www.statatlas-schweiz.admin.ch www.statatlas-politik.admin.ch www.statatlas-of-europe.admin.ch
Atlas of Austria	http://oerok-atlas.at/gui/map/php
Atlas of Canada	http://atlasducanada.com/site/english/toporam/index.html
Espon Atlas	http://mapfinder.espon.eu/
Observatory of DATAR territories	http://carto.observatoire-des-territoires.gouv.fr
OECD eXplorer	http://stats.oecd.org/OECDregionalstatistics/
UK cancer e-Atlas	http://www.ncin.org.uk/cancer_information_tools/eatlas
Atlas INED World demography atlas	http://www.ined.fr/fr/tout_savoir_population/atlas_population/
AIRE	http://aire.ums-riate.fr
HyperAtlas	http://hypercarte.imag.fr/realisations.hyperatlas.html#download
GapMinder	http://www.gapminder.org/world/
Harmonie-cités	http://atlasvillesusa.parisgeo.cnrs.fr/
Trajectories of Cyclones in Réunion Island 2011-2012	www.meteo.fr/temps/domtom.La_Reunion/webcnrs9.0/franais/iindex.html
Tajectory of the radioactive cloud of Tchernobyl	http://www.irsn.fr.FR/popup/Pages/tchernobyl_video_nuage.aspx
Communters in Grenoble	http://tel.archives-ouvertes.fr/tel-00420343/fr/
Velib in Paris	http://www.dailymotion.com/video/xxxhum_dynamique-du-velib-durant-le-jour-de-semaine-moyen_tech#.UY7ESYX0PR0
Eurostat Inflation dashboard	http://epp.eurostat.ec.europa.eu/inflation_dashboard/
Cartograms	http://www.gislounge.com/area-cartograms-explored/
Anamorphoses World Mapper Project	www.worldmapper.org http://mappemonde.mgm.fr/num17/articles/art08105.html
Commuting Scales Chôros	http://choros.ch/cs/
Continous 3D map	http://mappemonde.mgm.fr/num14/articles/art07202.html

Smooth and 3D representations	http://www.meipokwan.org/Gallery/Density.htm
Panoramio	http://www.panoramio.com/

Portals

OpenStreetMap	http://www.openstreetmap.org/
GoogleEarth	http://www.google.fr/intl/fr/earth/index.html
Géoportail IGN	http://www.geoportail.gouv.fr/accueil
Google Maps	http://www.google.fr/maps

Cartographical software and GIS

ArcGIS	http://www.esrifrance.fr/arcgis.aspx
ArcGIS Online	http://www.esri.com/software/arcgis/arcgisonline
Cartes et données	http://www.articque.com/solutions/cartes-donnees-edition-professionnelle/l-organigramme-coeur-du-logiciel.html
MapInfo	http://www.pbinsight.com/welcome/mapinfo/
PhilCarto	http://philcarto.free.fr/
Quantum GIS	http://www.qgis.org/fr.html

Solutions for Spatio-temporal exploration and visualization

CartoVista Solution for interactive cartographic application	http://www.cartovista.com/see.aspx
CommonGIS	www.commongis.com
VisStamp A Visualization System for Space-Time and Multivariate Patterns	http://www.spatialdatamining.org/software/visstamp
Dynmap	http://www.dynmap.com/
GeoDa	http://geodacenter.asu.edu
Geovista GeoViz Toolkit	http://www.geovista.psu.edu/software/ www.geovista.psu.edu/geoviztoolkit/